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LIST OF JOURNALS.

In 1901 *Abstracts were made from the following Journals. An asterisk* (*) *indicates that the Journals so marked were received only occasionally.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Acad. Sci. Cracovie, Bull.	Bulletin de l'Académie des Sciences de Cracovie	Single copy, 90 centimes ; 8 francs per annum	Librairie de la Société anonyme polonaise. Cracovie
Acad. Sci. St. Pétersbourg, Bull....	Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg	Single copy, 2 marks 50 pfennigs	Published by the Academy
Acad. Sci. St. Pétersbourg, Mém.	Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg	Single copy, 3 marks.....	Published by the Academy
Accad. Lincei, Atti	Atti della R. Accademia dei Lincei, Roma	——	Published by the Academy
Accad. Sci. Torino, Atti.....	Atti della R. Accademia delle Scienze di Torino	——	Published by the Academy
Akad. Wiss. Wien, Sitz. Ber.	Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, Wien	Single copies, 2s. 4d. to 7s. 6d.	Carl Gerold's Sohn, Barbaragasse 2, Vienna
Amer. Acad., Mem.	Memoirs of the American Academy of Arts and Sciences	——	American Academy of Arts and Sciences, 101–2, Beacon Street, Boston.
Amer. Acad., Proc.....	Proceedings of the American Academy of Arts and Sciences	——	Published by the Academy (as above)
*American Architect	The American Architect.....	——	——
Amer. Assoc., Proc.	Proceedings of the American Association for the Advancement of Science	——	Amer. Assoc. for the Advancement of Science, Salem, Mass., U.S.A.
Amer. Electn.	American Electrician	Single copy, 10 cents ; $1 per annum	120, Liberty Street, New York.
Amer. Inst. Elect. Engin., Trans.	Transactions of the American Institute of Electrical Engineers	Single copy, 50 cents ; $5 per annum	Published by the Institute, 26, Cortlandt Street, New York
Amer. Journ. Sci.	American Journal of Science.....	$6.40 per ann., post free	Tuttle, Morehouse & Taylor, 125, Temple Street, New Haven, Connecticut, U.S.A.
Amer. Phys. Soc., Bull	Bulletin of the American Physical Society	——	——
Amer. St. Rly. Assoc.....	Report of the American Street Railway Association	——	2020 State Street, Chicago
Ann. d. Physik	Annalen der Physik.....	38 marks per annum.....	J. A. Barth, Rossplatz 17, Leipzig

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Annal. Chim. Phys.	Annales de Chimie et de Physique	36 francs per annum	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
Annal. Scientifiques de l'Univ. de Jassy	Annales Scientifiques de l'Université de Jassy	10 francs per volume	——
Archiv Math. Phys.	Archiv der Mathematik und Physik	12 marks per annum	B. C. Teubner, Poststr. 3, Leipzig
Archiv Post,Tele.	Archiv für Post und Telegraphie	——	Published by the Reichs-Postamt, Berlin
Archives d'El. Médicale	Archives d'Électricité Médicale	22 francs per annum	O. Doin, Place de l'Odéon 8, Paris
Archives Néerlandaises	Archives Néerlandaises des Sciences Exactes et Naturelles	6 fl. per volume	Martinus Nijhoff, La Haye, Holland
Archives des Sciences	Archives des Sciences Physiques et Naturelles, Genève	Single copy, 2.50 francs ; 25 francs per annum	Bureau des Archives, 18 Pélisserie, Geneva
Assoc. Ing. El. Liège, Bull.	Bulletin de l'Association des Ingénieurs-Electriciens, Liège	20 francs per annum	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Assoc. Suisse Élect., Ann.	Annuaire de l'Association Suisse des Électriciens	——	J. Bollmann, Zurich, Switzerland
Astrophys. Journ.	Astrophysical Journal	Single copy, 50 cents ; 18s. per annum	The University of Chicago Press, Chicago, and W. Wesley & Son, 28, Essex Street, Strand, W.C.
Automotor Journ.	Automotor and Horseless Vehicle Journal	Single copy, 6d. ; 7s. per annum	F. King & Co., Ltd., 62, St. Martin's Lane, London, W.C.
Bureau des Longitudes, Ann.	Annuaire publié par le Bureau des Longitudes	1 franc 50 centimes	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Cambridge Phil. Soc., Proc.	Proceedings of the Cambridge Philosophical Society	Single copy, 2s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Cambridge Phil. Soc., Trans.	Transactions of the Cambridge Philosophical Society	Single copy, 7s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Canad. Elect. News	Canadian Electrical News	Single copy, 10 cents ; $1 per annum	C. H. Mortimer Publishing Co., Ltd., Confederation Life Buildings,Toronto,Canada
Canad. Inst., Proc.	Proceedings of the Canadian Institute	——	Arbuthnot Bros. & Co., Lombard Street, Toronto, Canada
Cassier	Cassier's Magazine	Single copy, 1s. ; 12s. per annum, post free	33, Bedford Street, Strand, W.C.
Centralblatt Accumulatoren	Centralblatt für Accumulatoren- und Elementenkunde	3 marks 50 pf. per quarter	W. Knapp, Halle a. S., Germany

LIST OF JOURNALS—*continued.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS OR AGENTS.
Chem. News	Chemical News and Journal of Science	Single copy, 4½d. post free	E. J. Davey, 6 & 7, Creed Lane, Ludgate Hill, E.C.
Chem. Soc., Journ.	Journal of the Chemical Society	——	Gurney & Jackson, 1, Paternoster Row, E.C.
Chem. Soc., Proc.	Proceedings of the Chemical Society	——	Gurney & Jackson, 1, Paternoster Row, E.C.
Comptes Rendus	Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences	34 francs per annum	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Deutsch. Phys. Gesell., Verh.	Verhandlungen der Deutschen Physikalischen Gesellschaft	4 marks per annum	——
Écl. Électr.	L'Éclairage Électrique	60 fr. per ann., post free	G. Carré & C. Naud, 3, Rue Racine, Paris
Elect. Engin.	Electrical Engineer	Single copy, 3d.; 13s. per annum, post free	139 & 140, Salisbury Court, Fleet Street, E.C.
Elect. Rev.	Electrical Review (London)	Single copy, 4d.; 19s. 6d. per annum, post free	Alabaster, Gatehouse & Co., 4, Ludgate Hill, E.C.
Elect. Rev. N.Y.	Electrical Review (New York)	Single copy, 10 cents; $5 per annum	Times Buildings, 41, Park Row, New York, & H. W. Hall, 42, Old Broad St., London, E.C.
Elect. World and Engineer	Electrical World and Engineer	Single copy, 10 cents; $6 per annum	120, Liberty Street, New York, & Hastings House, Norfolk Street, Strand, London
Electrician	The Electrician	Single copy, 6d.; 26s. per annum	Salisbury Court, Fleet Street, E.C.
Électricien	L'Électricien	Single copy, 50 centimes; 25 francs per annum	L. de Soye et Fils, Rue des Fossés-St.-Jacques 18, Paris
Electricity, N.Y.	Electricity (New York)	Single copy, 10 cents; $4.50 per annum	136, Liberty Street, New York
Electro-Chemist	The Electro-Chemist and Metallurgist	Single copy, 6d.; 7s. 6d. per annum, post free	Sherard Cowper-Coles & Co., Ltd., 82, Victoria Street, Westminster
Elekt. Runds.	Elektrotechnische Rundschau	12 marks per annum	10, Kaiserstrasse, Frankfurt a. M., Germany
Elektrochem. Zeitschr.	Elektrochemische Zeitschrift	18 marks 40 pfg. per ann.	M. Krayn, 86, Steglitzerstrasse, Berlin, W.
Elektrotechn. Zeitschr.	Elektrotechnische Zeitschrift	25s. per annum	J. Springer, 24, Monbijouplatz 3, Berlin
Elettricità, Milan	L'Elettricità (Milan)	Single copy, 25 centesimi; 18 lire per annum	Via Cusani 11, Milano, Italy
Engineer	The Engineer (London)	Single copy, 6½d. post free; £1 9s. per ann., post free	33, Norfolk Street, Strand, W.C.
Engineering	Engineering	Single copy, 6½d. post free; £1 9s. 2d. per annum, post free	35 & 36, Bedford Street, Strand, W.C.

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Eng. Club, Phil., Proc.	Proceedings of the Engineers' Club of Philadelphia	$2 per volume	1122, Girard Street, Philadelphia
Eng. Mag.	The Engineering Magazine	Single copy, 1s.; 12s. 6d. per annum, post free	222–225, Strand, London, W.C.
Eng. News	Engineering News	Single copy, 15 cents; $6.31 per annum	220, Broadway, New York, and Effingham House, 1, Arundel Street, Strand, London
Eng. Record	The Engineering Record	Single copy, 12 cents; $6 per annum	100, William Street, New York
Feilden	Feilden's Magazine	Single copy, 1s.; 12s. 6d. per annum, post free	Temple Chambers, Embankment, London, E.C.
Frank. Inst., Journ.	Journal of the Franklin Institute	Single copy, 50 cents; $5 per annum	Franklin Institute, Philadelphia
Génie Civil	Génie Civil	Single copy, 1 franc; 45 francs per annum	Rue de la Chaussée d'Antin 6, Paris
Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse	Nachrichten der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-physikalische Klasse	——	Lüder Horstmann, Göttingen, Germany
Horseless Age	The Horseless Age	Single copy, 10 cents; $4 per annum	E. P. Ingersoll, 150, Nassau St., New York
Ind. Élect.	L'Industrie Électrique	Single copy, 1 franc; 26 francs per annum	A. Lahure, 9, Rue de Fleurus, Paris
Ind. Electrochim.	L'Industrie Électrochimique	Single copy, 60 centimes; 8 francs per annum	H. Becker, 5, Rue Guy-Patin, Paris.
Inst. Civ. Engin., Proc.	Proceedings of the Institution of Civil Engineers	——	Published by the Institution, Great George Street, London, S.W.
Inst. Elect. Engin., Journ.	Journal of the Institution of Electrical Engineers	Single copy varies from 1s. 6d. to 7s. 6d.	E. & F. N. Spon, 125, Strand, London, W.C.
Inst. Engin. and Shipbuilders, Trans.	Transactions of the Institution of Engineers and Shipbuilders in Scotland	——	Published by the Institution, 207, Bath Street, Glasgow
Inst. Mech. Engin., Proc.	Proceedings of the Institution of Mechanical Engineers	——	Published by the Institution, Storey's Gate, St. James's Park, London, S.W.
Inst. Naval Architects, Trans.	Transactions of the Institution of Naval Architects	——	H. Sotheran & Co., 140, Strand, London, W.C.
International Electrical Congress at Paris, Reports	Rapports et Procès Verbaux présentés au Congrès International d' Électricité, Paris, 1900	——	Gauthier-Villars, Quai des Grands-Augustins 55, Paris

LIST OF JOURNALS—*continued.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
nternational Physical Congress at Paris, Reports	Rapports présentés au Congrès International de Physique, Paris, 1900	40 francs	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
nternational Tramway Congress at Paris, Comptes Rendus	Comptes Rendus detaillés du Congrès International des Tramways, Paris, 1900, organisé sous les auspices de l'Union Internationale Permanente de Tramways	——	Published by the Society; Secretary, F. Nonnenberg, 85, Rue Potagère, Brussels
Journal of Electricity, S. F.	Journal of Electricity, Power, and Gas (San Francisco)	Single copy, 10 cents ...	315, Cherry Street, San Francisco, Cal., U.S.A.
Journ. Phys. Chem.	Journal of Physical Chemistry	$4 per annum	Published at Cornell University, U.S.A.
Journ. de Physique.....	Journal de Physique	15 fr. per ann., post free	11, Rue Rataud, Paris
Journ. Télégraph.	Journal Télégraphique	Single copy, 50 centimes; 5 francs per annum	Bureau International des Administrations Télégraphiques, Berne
Lightning.....	Lightning	Single copy, 2d.; 10s. 6d. per annum	8, Bream's Buildings, Chancery Lane, W.C.
Locomotion Automobile	La Locomotion Automobile	Single copy, 5 centimes; 20 francs per annum	Place de la Madeleine, Rue Chauveau-Lagarde 4, Paris
Manchester Lit. and Phil. Soc., Mem.	Memoirs of the Manchester Literary and Philosophical Society	Single copy, 2s.	36, George Street, Manchester
Mech. Eng.	The Mechanical Engineer	Single copy, 6d.; 20s. per annum, post free	53, New Bailey Street, Manchester
Metallographist	The Mettallographist	Single copy, 80 cents; $3 per annum.	Boston Testing Laboratories, 446, Tremont Street, Boston, U.S.A.
Monthly Weather Rev.	The Monthly Weather Review.....	Single copy, 10 cents ...	Published by the U.S. Weather Bureau, Washington
N. Cimento	Nuovo Cimento.....	20 lire per annum	A. Lavacchini, Via Sino Capponi 3, Firenze
Nature	Nature.....	Single copy, 6d.	Macmillan & Co., Ltd., St. Martin's Street, London, W.C.
Nova Scotian Inst., Trans.	Transactions of the Nova Scotian Institute of Science	——	Published by the Institute, Halifax, Nova Scotia
Phil. Mag.	London, Edinburgh, & Dublin Philosophical Magazine	2s. 6d. per month, occasionally 5s.	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Phys. Rev.	Physical Review	Single copy, 50 cents;	Macmillan & Co., Ltd., London and New

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Phys. Soc., Proc.	Proceedings of the Physical Society of London	——	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Phys. Zeitschr.	Physikalische Zeitschrift	5 Mk. per quarter, or 25 Mk. per ann., post free	S. Hirzel, Königstrasse 2, Leipzig
Preuss. Akad. Wiss. Berlin, Sitzb.	Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin	12 marks per annum	Königliche Akademie der Wissenschaften, Berlin
Railroad Gazette	Railroad Gazette	$6.08 per ann., post free	32, Park Place, New York
Revue de l'El, Berne	Revue de L'Électricité, Berne	8 francs per annum	Place de l'Ours 29, Berne
Revue Int. d'Électrothérapie	Revue Internationale d'Électrothérapie et de Radiothérapie	Single copy, 50 centimes; 6 francs per annum	3, Place du Théâtre Français, Paris
Revue Scientif.	Revue Scientifique	Single copy, 60 centimes; 35 francs per annum	19, Rue des Saints Peres, Paris, and T. F. Unwin, 11, Paternoster Square, E.C.
Rivista Sci.-Industriale	Rivista Scientifico-Industriale	12 lire per annum	2, Lungarno della Zecca, Firenze, Italy
Roy. Dublin Soc., Proc.	Scientific Proceedings of the Royal Dublin Society	Single copy, 6d.	Published by the Society, Leinster House, Dublin
Roy. Dublin Soc., Trans.	Transactions of the Royal Dublin Society	——	Published by the Society, Leinster House, Dublin
Roy. Inst., Proc.	Proceedings of the Royal Institution of Great Britain	——	Published by the Institution, 21, Albemarle Street, W.
Roy. Soc. Canada, Proc.	Proceedings of the Royal Society of Canada	——	——
Roy. Soc. N. S. Wales, Journ. and Proc.	Journal and Proceedings of the Royal Society of New South Wales	——	5, Elizabeth Street, Sydney, New South Wales
Roy. Soc., Phil. Trans.	Philosophical Transactions of the Royal Society of London	Varies for separate papers, from 1s.	Dulau & Co., 37, Soho Square, London, W.
Roy. Soc., Proc.	Proceedings of the Royal Society of London	Varies for separate parts, from 1s. 6d.	Dulau & Co., 37, Soho Square, London, W.
Roy. Soc. Queensland, Proc.	Proceedings of the Royal Society of Queensland	——	Pole & Co., 95, Elizabeth Street, Brisbane
Roy. Soc. Victoria, Proc.	Proceedings of the Royal Society of Victoria	——	Published by the Society, Melbourne. London Agents: Williams & Norgate, 14, Henrietta Street, Covent Garden, W.C.
*Russian Electrotechnical Courier	Russian Electrotechnical Courier	——	——
Schweizerische Blätter für Elektrotechnik	Schweizerische Blätter für Elektrotechnik, Berne	8 francs per annum	Place de l'Ours 29, Berne

LIST OF JOURNALS—*continued.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Science	Science	Single copy, 15 cents	Macmillan & Co.,66,Fifth Avenue,New York
Scientific American	Scientific American	Single copy,8cents; 16s.5d. per annum, post free	361, Broadway, New York
Scientific Australian	Scientific Australian	2s. 6d. per annum, post free	Turner & Henderson, 16–18, Hunter Street, Adelaide
Soc. Arts, Journ.	Journal of the Society of Arts	Single copy, 6d.	G. Bell & Sons, York St., Covent Garden, W.C.
Soc. Belge Elect., Bull.	Bulletin de la Société Belge d'Électriciens	Single copy, 2 francs ; 20 frs. per ann., post free	54, Rue Froissart, Brussels
Soc. Chem. Ind., Journ.	Journal of the Society of Chemical Industry	30s. per annum	Published by the Society, 9, Bridge Street, Westminster, S.W.
Soc. Franç. Phys., Bull	Bulletin de la Société Française de Physique	——	Published by the Society, 44, Rue de Rennes, Paris
Soc. Franç. Phys., Séances	Séances de la Société Française de Physique	——	Published by the Society (as above)
Soc. Imp. Nat. Moscou, Bull.	Bulletin de la Société Impériale des Naturalistes de Moscou	——	J. N. Kouchnereff & Co., Pimenowskaia, Moscou
Soc. Int. Élect.. Bull.	Bulletin de la Société Internationale des Électriciens	Single copy, 2.50 francs ; 27 francs per annum	Gauthier - Villars, Quai des Grands-Augustins 55, Paris
Street Rly. Journ.	Street Railway Journal	Single copy, 50 cents ; $6 per annum, post free	A. C. Shaw, Hastings House, Norfolk Street, Strand, W.C.
Street Rly. Rev.	Street Railway Review	Single copy, 30 cents ; $4 per annum	Windsor and Kenfield Publishing Co., Monon Building, Chicago
Tech. Versuch. Berlin, Mitth.	Mittheilungen der Technischen Versuchanstalten zu Berlin	12 marks per annum	J. Springer, 24, Monbijouplatz 3, Berlin
*Technology Quarterly	Technology Quarterly	——	——
Terrestrial Magnetism	Terrestrial Magnetism and Atmospheric Electricity	Single copy, 75 cents ; $2.75 per annum	Johns Hopkins Press, Baltimore, U.S.A.
Tram. Rly. World	Tramway and Railway World	Single copy, 1s. post free	Amberley House, Norfolk Street, W.C.
U.S. Weather Bureau, Bull.	Bulletin of the United States Weather Bureau	——	Published by the U.S. Weather Bureau, Washington
Union Int. Permanente de Tramways, Questionnaire	Congrès International des Tramways, Paris, 1900, organisé sous les auspices de l'Union Internationale Permanente de Tramways. Réponses au Questionnaire	——	Published by the Society ; Secretary, F. Nonnenberg, 85, Rue Potagère, Brussels.

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
West. Electn.	Western Electrican (Chicago)	Single copy, 10 cents; $3 per annum	510, Marquette Buildings, Chicago, and 44, Fleet Street, London, E.C.
Western Soc. Engin., Journ.	Journal of the Western Society of Engineers	$2 per volume of six numbers	Published by the Society, 1734–41, Monadnock Block, Chicago
Zeitschr. Elektrochem.	Zeitschrift für Elektrochemie	4 marks per quarter	W. Knapp, Halle a. S., Germany
Zeitschr. Elektrotechn., Wien	Zeitschrift für Elektrotechnik (Wien)	30 fr. per ann., post free	Nibelungengasse 7, Vienna
Zeitschr. Instrumentenk.	Zeitschrift für Instrumentenkunde	20 marks per annum	J. Springer, 24, Monbijouplatz 3, Berlin
Zeitschr. Instrumentenk., Beib.	Beiblatt zur Zeitschrift für Instrumentenkunde		
Zeitschr. Phys. Chem.	Zeitschrift für Physikalische Chemie	Single copy about 4s. 3d.	W. Engelmann, Leipzig
Zeitschr. Vereines Deutsch. Ing.	Zeitschrift des Vereines Deutscher Ingenieure	Single copy, 1 mark 40 pfg.; 32 marks per annum, post free	J. Springer, Monbijouplatz 3, Berlin

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ERRATA.

Abstract No. 102, line 13 : *for* increases more slowly, *read* decreases more slowly.

No. 593, line 1 : *for* F. H. Minshall, *read* T. H. Minshall.

No. 627, line 13 from end : *for* 3·69Q, *read* 3·68Q.

No. 757, line 1 : *for* H. Halshof, *read* H. Hulshof.

No. 853, line 2 from end : *for* special, *read* spiral.

No. 1096, line 2 from end : *for* emit, *read* exert.

No. 1096, line 13 from end : *for* tested *read* treated.

No. 1292, line 2 from bottom : *for* $\kappa T/PV$, *read* kT/PV.

No. 1355, line 6 : *for* $Cu_3.COBr$, *read* $CH_3.COBr$.

No. 1395, line 1 : *for* G. Pierard, *read* E. Pierard.

No. 1443, line 11 : *for* 9-inch, *read* quick.

No. 1466, line 2 : *for* Electrician, *read* Électricien.

No. 1641, line 6 from bottom : *for* $K - 1 = \Sigma \frac{Ne^2}{4\pi m}\lambda^2$, *read* $K - 1 = \Sigma \frac{Ne^2}{\pi m}\lambda^2$.

(Erratum by Author after publication of original paper.)

No. 1741, line 3 : *for* May 20, *read* May 29.

No. 1807, line 1 : *for* J. Jones, *read* J. Jonas.

No. 1909, line 8 : *for* source at T_2, *read* source at T_1.

No. 1968, line 7 : *for* 600 HCl, *read* N/600 HCl.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1901.

GENERAL PHYSICS.

1. *Hardness of Metals.* **F. Auerbach.** (Ann. d. Physik, 3. 1. pp. 108–115. Sept., 1900.)—The author's definition of hardness is given for the case of plastic bodies, including metals, by the limiting pressure per unit surface, attainable between a lens and a plate of the same substance. In the case of metals the deformation cannot be observed with the same facility as in the case of transparent bodies, but the surface of contact may be measured by covering the lens with a thin layer of lampblack. This is only necessary at small pressures, since at great pressures the deformed area retains its shape. A complication is introduced by the fact that the hardness is considerably influenced by small impurities, as well as by the elastic and thermal history of the metal. The author gives the following table of the hardnesses of various fairly well-defined metals, as compared with minerals :—

Steel	361	Quartz.
Copper (hard)	143	Apatite.
Bronze	127	
Brass	107	Fluorspar.
Gold	97	
Copper	95	Calcspar.
Silver	91	
Aluminium	52	Boracic Acid.
Lead	10	Gypsum.

The aluminium was alloyed with 6 per cent. copper. The bronze was an alloy of 15 parts copper, 2 parts zinc, and 1·5 tin. The brass contained 2 parts copper to 1 of zinc. E. E. F.

2. *Elasticity and Hardness of Silica.* **F. Auerbach.** (Ann. d. Physik, 3. 1. pp. 116–119, Sept., 1900.)—Silica was obtained in three forms : crystallised as rock crystal, amorphous as a glass, and amorphous with admixture of water in the form of opal. In every case the hardness is sensibly proportional to the elasticity, except in glass, which is somewhat harder. Both the elasticity and the hardness of the amorphous silica are smaller than the smallest values for rock crystal. The elasticity and hardness

of opal are only about half those of amorphous silica. The first difference is probably connected with the fact that quartz expands during amorphous solidification, its density then being only 83 per cent. of its density as rock crystal. The softness of opal is due to the admixture of water. E. E. F.

3. *Elasticity of Metals, and Temperature.* **A. Gray, V. J. Blyth,** and **J. S. Dunlop.** (Roy. Soc., Proc. 67. pp. 180–197, Oct. 31, 1900.)—The Young's and rigidity moduli of several different metals in the form of wires are here determined at different temperatures between atmospheric temperature and 100° C. The metals used were German silver, mild steel, brass, copper (commercial), copper (hard-drawn electrolytic), and soft iron, and the results are given in tabular form in the paper. In determining the rigidity moduli by the vibration method, the authors noticed that temperature has a considerable effect on the decrement of the vibrations. The decrement appears to be a function of the temperature and of the amplitude of vibration, but the authors purpose experimenting still further on this point. German silver appears to behave differently from all the others in this alteration of decrement with temperature, the decrement being smaller at the high temperatures in its case, instead of larger as in the case of the others. The decrement is also a function of the weight of the vibrator and of the previous history of the wire. J. B. H.

4. *Contact Deformations of Elastic Bodies.* **A. Lafay.** (Comptes Rendus, 131. pp. 525–528, Sept. 17, 1900.)—The author describes experiments on the deformations of two spheres in contact with each other, or a sphere in contact with a plane, the materials being generally bronze or steel. The method of measuring these deformations is an optical one analogous to that employed by Fizeau for studying the dilation of crystals. The radii of the spheres used varied from 5 mm. to 250 mm., and the force of compression from a few grammes to 3·7 kg. A table is given of results which vary from 0·14 microns for steel spheres of radius 250 mm., pressed together with a force of 0·1 kg., to 2 microns for spheres of radius 5 mm., and a force of 3·0 kg. These values are compared with the theoretical deformations as given by Hertz's mathematical theory of elasticity. E. C. R.

5. *Elasticity of Wires.* **H. E. Wimperis.** (Phil. Mag. 50. pp. 416–420, Oct., 1900.)—In the Phil. Mag. for Feb., 1900 [see Abstract No. 795 (1900)], G. F. C. Searle described an apparatus for determining the elastic constants for wires of different metals. With it he found the value of Poisson's ratio for certain metals greater than $\frac{1}{3}$. The author extends these experiments to wires of larger diameter (from $\frac{1}{10}$ inch to $\frac{1}{4}$ inch), the diameters of the wires used by Searle being from $\frac{1}{25}$ inch to $\frac{1}{16}$ inch. The apparatus used is similar to Searle's but much larger, the moment of inertia of the vibrating rods being six times as great. The paper gives a description of the apparatus and method of using it. In no case was the value of Poisson's ratio found greater than 0·461; this, in view of Searle having obtained several values above 0·5, is of interest as illustrating a possible effect of the increase of diameter of the wires used. E. C. R.

6. *Explosive Effects of Bullets.* **C. Cranz** and **K. R. Koch.** (Ann. d. Physik, 3. 2. pp. 247–273, Oct., 1900.)—The question investigated by the authors was whether the "explosion" of tissues produced by a high-velocity infantry bullet takes place while the bullet is still within the body, or after it

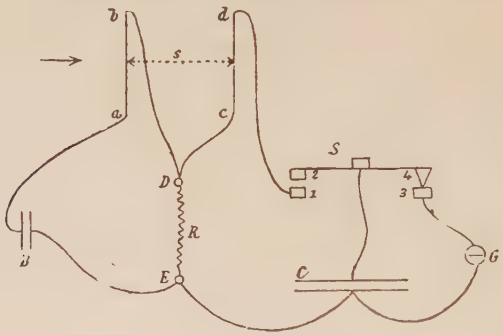
has already left it. To imitate the action of blood-vessels while having recourse to a clearly defined physical structure, the authors employed tin cylinders filled with water, and closed at one end with parchment, and at the other with an indiarubber membrane. The rifle experimented with was a new 6 mm. model made by Mauser at Oberndorf, and having a muzzle velocity of 100 m. in excess of any hitherto used. The method of taking the photographic records was a modification of that devised by Mach. The circuit of a battery of Leyden jars was interrupted by two spark-gaps. One of them lies within the liquid, or in its immediate neighbourhood. Its knobs are covered with glass tubes, so that the spark can only pass when they are shot through. The other spark-gap lies in front of a concave mirror in such a position that its image falls on the shutter of the recording camera. This gives a silhouette of the water-vessel on the sensitive plate. In some of the experiments, the bending aside of the bullet by the water made it necessary to have another method of making the circuit. This was then done by the mechanical action of the issuing water-jet in bringing one electrode into contact with the other. The general result of the experiments is that the "explosion" takes place some time after the bullet has left the body. The authors discuss the various theories framed to account for the phenomenon. It is not due to evaporation, as the temperature of the bullet in no case exceeds 150°. The introduction of large masses of gas into the body has no evidence to support it. The rotation of the bullet is too slight to produce the effect, and the deformation of the bullet cannot be the main cause, as explosive effects are produced when there is no deformation. The only remaining theories are that based on sound waves and on the acquired velocity of translation. The authors favour the latter. Part of the kinetic energy of the bullet is transferred to parts of the body in the vicinity of the path of the bullet, and takes some time to produce its effect. But when this takes place a considerable portion of the body is torn away from the anterior portion. E. E. F.

7. *Permanent Deformations of Metallic Wires.* **E. Lenoble.** (Journ. de Physique, 9. pp. 532–543, Oct., 1900.)—This paper deals with the relations between the fractional increase in length of a wire stretched vertically and loaded at its lower end, and the load per unit of area. Arrangements were made for increasing and decreasing the load gradually. The experiments are divided into two classes—those with loads much under the breaking load, and those with loads in the vicinity of the breaking load. The wires were in most cases given a definite load, and this load increased by steps to a higher value, and then decreased by the same steps to the original value, this cycle being repeated over and over again until the hysteretic loop attained a limiting value. E. C. R.

8. *Measuring Speed of Bullets.* **M. Radaković.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 276–283, April, 1900.)—This paper describes a method of determining the velocity of a bullet by the time of discharge of a condenser, using the equation $q = q_0 \varepsilon^{-\frac{t}{RC}}$ where q is the charge in condenser after t secs., q_0 is initial charge, R the resistance of a non-inductive discharger, and C the capacity of the condenser.

The condenser C is charged by the cell B on pressing the 1-2 side of the key S. On releasing the key the charge q_0 is found by means of the ballistic galvanometer G. Having carried out this preliminary measurement,

the key 1-2 is pressed down, and the shot fired so as to sever the gratings *ab*, *cd*, in succession. This effects first the cutting out of the battery, and second the stopping of the condenser discharge. By releasing the key again the residual charge q is found; and hence t and v. Sabine used this method in 1876, but his results were not concordant. The author's experiments were made with an infantry rifle of 8 mm. bore, and the first screen



ab was 10 metres from the muzzle. In one experiment B was a single accumulator cell, C 1·1 microfarad, R 1,354 ohms.

Values of v in metres per second were found as follows :—

s = 48·4 cm.	s = 28·6 cm.	s = { 8·85 cm. / 8·5 cm.
611·2	598·9	599·3
607·6	633·5	631·0
631·4	...	...
Mean = 616·7	Mean = 616·2	Mean = 615·1

A weak E.M.F., good insulation, and a sensitive ballistic galvanometer are necessary for a successful determination of velocity, and the error in the measurement of t is smallest when $q/q_0 = 0{\cdot}278$. Other experiments showed there was no perceptible slowing down due to the resistance of the gratings shot through. G. E. A.

9. *Thermal and Electrical Conductivities.* **E. Grüneisen.** (Ann. d. Physik, 3. 1. pp. 43–74, Sept., 1900.)—The author studies the influence of impurities in metals upon the ratio of their electric and thermal conductivities. The method of determining the thermal conductivity is that devised by Schulze [see Abstract No. 803 (1899)], but the bar of metal was itself made one of the elements of the thermo-couple. Eight different bars were examined. One of them was pure copper. A second, denoted by CuAs1, contained traces of arsenic; and a third, CuAs2, contained considerable traces of it. The fourth was an iron bar, denoted by FeWA14, and containing 0·1 per cent. carbon and traces of Cu, Si, Mn, P, and S. Another iron bar, FeWA2, contained 0·57 per cent. of carbon, and 0·21 of silicon. FeWA3 contained more carbon and less silicon, and FeWA4 contained 1·5 per cent. of carbon, 0·19 of Mn, and 0·05 Si. A nickel-copper alloy con-

taining 46 per cent. of Ni was also examined. The following table gives the results in c.g.s. units per 18° C.

Substance.	Electric Conductivity $\kappa \times 10^5$.	Thermal Conductivity λ.	$\frac{\lambda}{\kappa} \times 10^{-1}$.
Cu	57·4	0·934	163
CuAs1	19·1	0·340	178
CuAs2	5·03	0·0995	198
FeWA14	9·89	0·171	173
FeWA2	6·10	0·124	203
FeWA3	6·12	0·123	201
FeWA4	5·51	0·119	216
NiCu	1·99	0·0484	243

Addition of foreign substances reduces the electric conductivity to a greater extent than the thermal conductivity. This is specially evident in iron. The electric conductivities of the four iron bars are in the ratio

$$1 : 0{\cdot}617 : 0{\cdot}619 : 0{\cdot}557.$$

The same ratios, calculated after Le Chatelier's rules, are

$$1 : 0{\cdot}631 : 0{\cdot}601 : 0{\cdot}496,$$

neglecting the traces of phosphorus, sulphur, and copper. E. E. F.

10. *Electrical Weighing and Recording Machine.* **E. McGarvey.** (Scientific American, 83. pp. 104–105, Aug. 18, 1900.)—The weight is applied through levers to a steel ribbon in tension; this ribbon is vibrated by an electromagnet with interrupter on the ribbon, and the intermittent current produced is passed through a second electromagnet (which may be at any distance) acting on a similar steel ribbon. The second ribbon will only vibrate actively when its period is the same as that of the first, *i.e.*, when their tensions are equal; this condition is obtained by varying the weights on a steelyard supporting the second ribbon. When this is in active vibration the weight stretching it is the same as that applied to the first ribbon.

In the instrument for recording weights, the second ribbon is replaced by a plate carrying a series of metal reeds similar to the set of reeds in a musical-box; each reed is tuned in unison with the first ribbon when stretched by a definite weight. The plate carrying the reeds is vibrated in unison with the ribbon by an electromagnet, and the reed corresponding with the rate of vibration is set into active vibration. Recording is done as follows: A strip of paper is passed over an insulated metal roller at a slight distance below the tips of the reeds; the metal roller and the reeds are joined to the two poles of the spark-gap of an induction coil. When no reed is vibrating the distance between them and the roller is such that the sparks pass across their normal spark-gap; when any reed vibrates, however, it approaches so close to the roller that the spark passes and perforates the strip of paper. G. H. B.

11. *Helmholtz Pendulum Interrupter.* **M. T. Edelmann.** (Ann. d. Physik, 3. 2. pp. 274–282, Oct., 1900.)—The author describes the pendulum interrupter manufactured by himself on Helmholtz's principles, with especial reference to the various devices for accurately determining the time interval between the two successive contacts. E. E. F.

12. *Thickness of Films.* **C. H. Sharp.** (Ann. d. Physik, 3. 2. pp. 210–220, Oct., 1900.)—The thickness of a thin deposit is obtained by making a model of it in a mixture of equal parts of colophonium and burgundy pitch. At the place where the thickness is to be determined, a small portion of the film is removed, and the mixture is laid on and warmed to 75° in a thermostat. It is lightly pressed in with the finger, after which the whole is allowed to cool slowly, and the impression is lifted off. It has a brilliant black surface. It is pressed on to a glass plate, and two systems of interference fringes are seen, one corresponding to the film and the other corresponding to the blank space. The discontinuity between the two systems is indicated by a displacement of the fringes, and the amount of the displacement measures the thickness. The author has devised a special spectrometer arrangement for exact measurements. He has measured the thicknesses of various layers of gelatine by this method. When the impression is lifted off, it does not stick, owing to a slight contraction on cooling. This contraction, while sufficient to facilitate detachment, is not large enough to interfere with the correctness of the measurements, since the mixture remains practically liquid until it arrives at the ordinary temperature. E. E. F.

13. *Diffusion of Gases and Liquids.* **H. T. Brown.** (Chem. News, 82. pp. 161–162, Oct. 5, 1900. Abstract of a paper read before the British Association.)—The author has made interesting experiments on the rate of diffusion of CO_2 towards an absorbing KOH solution. If no diaphragm be used the rate of absorption is proportional to the *area* of the opening. If, however, a diaphragm be used in perfectly still air, "vena contracta" effects come in, and the rate of flow tends to become proportional to the *diameter* of the opening. F. G. D.

14. *Surface Tension of Water above* 100° *C.* **C. T. Knipp.** (Phys. Rev. 11. pp. 129–154, Sept., 1900.)—Owing to the way in which water attacks glass at high temperatures it was necessary to use some other material for the containing vessel. A steel vessel plated inside with platinum (or copper) was used. The method consisted in determining the force required to lift a platinum vane partly submerged in water. The force was obtained by utilising the ponderomotive force exerted by a coil carrying a current. The temperatures were measured by a Cu-Pt thermo-junction. The apparatus was electrically treated and the movement of the vane electrically signalled. The author determined not only the surface tensions (from 100° C. to the critical temperature) but also the critical constants. The critical temperature was found to be 359° C. and the pressure 205 atmospheres. The surface tension was found to decrease linearly with increase of temperature until near the critical temperature, when it fell to zero very rapidly. F. G. D.

15. *Measurement of Surface Tension.* **J. S. Stevens.** (Amer. Journ. Sci. 10. pp. 245–246, Sept., 1900.)—The method of measurement employed is as follows: An iron wire is bent into the form of a T and the cross allowed to float on the surface of water. The body of the T projects a little distance into the centre of a coil of copper wire through which a current may pass. The part of the T forming the plunger is adjusted so that its weight is nearly sufficient to break through the liquid surface. A slight pull towards the centre of the coil due to the passage of the current will then accomplish this. The system is raised and lowered by a rack and pinion so that it may be placed on the liquid surface as gently as possible. By means of a continuous resistance

the current may be applied in small increments. On the passage of the current the plunger moves to the centre of the coil and the pull is then steadily applied to the centre of inertia of the system. The magnetic force may be calibrated at leisure by use of a balance, or it may be calculated from the constants of the coil. This in proper units must be added to the weight of the system. J. J. S.

16. *Viscosity of Gases.* **Rayleigh.** (Roy. Soc., Proc. 67. pp. 137–139, Oct. 26, 1900.)—The author has tested this influence of variations of temperature upon the viscosity of helium, and has found that the temperature coefficient is the same as in hydrogen. The constant c in Sutherland's equation comes out as 72·2 for hydrogen and helium, and this value, together with those for air, oxygen, and argon, agrees well with the values calculated by Sutherland from Obermayer's observations. E. E. F.

17. *Surface Tensions of Liquefied Gases.* **L. Grunmach.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 38. pp. 829–838, July 26, 1900.)—Determinations by the method of capillary ripples of the surface tensions of liquefied SO_2, NH_3, chlorine and of "Pictet's Liquid" (SO_2 and CO_2 in molecular proportions). Results :—

Liquid.	Surface tension (in dyne/cm.'s).	Temp.
Sulphur dioxide	33·285	— 25° C.
Pictet's Liquid	35·065	— 33° C.
	38·209	— 60° C.
Ammonia	41·778	— 29° C.
Chlorine	33·6493	— 72° C.

The molecular weights of the three pure liquids were calculated from the formula $av^{\frac{2}{3}} = 2{\cdot}27(\theta - t)$ (Eötvös—Ramsay—Shields).

Only these single determinations were employed, and the critical temperatures (θ) were taken to be : 157° C. (SO_2), 130·5° C. (NH_3), and 145° C. (chlorine). The densities employed in the calculation were :—

Sulphur dioxide	$d_{-25} = 1{\cdot}5016$
Ammonia	$d_{-29} = 0{\cdot}6703$
Chlorine	$d_{-72} = 1{\cdot}6452$

The molecular weights so calculated are as follows :—

Sulphur dioxide	65·66
Ammonia	17·10
Chlorine	92·14

According to these results, sulphur dioxide and ammonia are non-associating liquids while chlorine is associating. F. G. D.

18. *Sailing Birds Dependent on Wave-Power.* **L. Hargrave.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 125–128, 1900.)—From observations of sailing-birds following ships the theory is here advanced that they are supported by the upward air-current on the rising side or face of the wave. The following numerical case is given as an example of the feasibility of this theory of sailing motion. Let a sea-wave 180 feet long and 10 feet high travel at 18 knots, or say, 30 feet per second, under *calm* air. This wave will raise all the air as it passes 10 feet, at a mean rate of $3\frac{1}{3}$ feet per second.

The rate will vary from zero in the trough, attaining its maximum velocity at half the wave height, or where the wave is steepest, and falling to zero at the crest. Let the maximum volocity of the uplift of the air be about 4 feet per second and the steepest part be of 10° slope. According to S. P. Langley, a plane surface 30 inches by 4·8 inches, weighing 1·1 lb., will glide on air, without losing its elevation, at a speed of 49·8 feet per second, if sloped 5°. That is, the plane pushes 4·33 feet of air vertically downwards whilst it is translated 49·8 feet in one second. The same effect with regard to the position of the plane at the end of its journey of one second's duration is produced if the plane be sloped 5° downwards, and the air through which it passes be pushed bodily upwards 4·33 feet in one second. Now the air over the wave under consideration is being lifted about 4 feet per second; so if the 1·1 lb. plane were launched with 5° downward slope in the same direction the wave is travelling, from one foot above the steepest part of the wave it would overrun the wave whose velocity is only 30 feet per second. It would thus get out of the air that is being lifted and shoot into the water in the trough. But let the aspect of the plane be changed so that it faces 53° to the right or left of the track of the wave, then its position above mean sea-level and situation on the wave-slope will be unaltered; and, if the wave were of unlimited width the plane would continue its course till dashed ashore.

If the horizontal velocity of 49·8 feet per second be changed to a vertical one, it suffices to raise the plane to an elevation of 38 feet in a second and a half. And from a poise at this station a swoop down may be made in any direction till another place of uplifting air is found, in which its horizontal course may be resumed as before. E. H. B.

19. *Multiple Space in Applied Mathematics.* **H. S. Carslaw.** (Electrician, 45. p. 864, Sept. 28, 1900. Abstract of a paper read before the British Association.)—The ordinary method of images may be used in the solution of problems in electrostatics, &c., when the bounding planes meet at an angle π/m, but it fails when the angle of inclination is $n\pi/m$, n and m being positive integers. Sommerfeld has suggested that a Riemann surface might here be employed, and with the help of a multiple space, problems in electrostatics, electric conduction, hydrodynamics, sound, and conduction of heat, in which the boundaries are planes meeting at an angle $n\pi/m$ may now be solved by images. The author illustrates the process by the potential problem in which the boundary is the semi-infinite plane $\theta = 0$, and another in which the boundary is the infinite plane with hemispherical bowl. In the latter case the physical space is considered as given by $0 < \theta < 3\pi/2$, and three revolutions of the radius vector are required to complete the multiple space. The poles are at $(\pm\,\theta')$, $(\pm\,[3\pi + \theta'])$. E. E. F.

20. *Theory of Gravitation.* **R. A. Fessenden.** (Elect. World and Engineer, 36. pp. 478–479, Sept. 29, 1900.)—The present article is a short note claiming for its author an explanation of gravitation as a secondary electric effect. The full theory is to be published elsewhere. The hypothesis here put forward has been obtained in continuation of previous work on the nature of the electromagnetic quantities and the density and the elasticity of the ether [see Abstracts Nos. 1233, 1234, 1235, 1277, 1278, and 1279 (1900)], and is based partly on the author's own experimental researches and partly on those of other physicists. The chief results may be summarised as follows:—(1) "All simple dielectrics expand under electric stress. The expansion varies as the square of the electric intensity or voltivity, and

inversely as the elasticity." (2) When we place a dielectric in an electric field, we have a change in the density of the *substance*, and a change in the density of the *ether*. The former gives us Kerr's phenomenon, the latter changes the weight of the condenser. (3) The value of the electrostatic stress at the surface of a corpuscle is of the order 10^{20}, and the elasticity of the ether has been shown to be of the order 6×10^{20}. There is accordingly an enormous stress next the corpuscle, producing a change of density, the amount of this change varying inversely with the fourth power of the distance from the centre of the corpuscle and the total amount of expansion varying inversely as the square. But Newton showed that a change of density in the medium surrounding a particle of matter would account for the gravitational attraction. And the present method of accounting for this change of density gives an effect of approximately the right order. Thus—(4) "Inertia is an electromagnetic induction effect, due to the corpuscular charge. (5) Gravitation is a secondary effect, the electrostatic intensity due to the corpuscular charge causing a change of density in the ether surrounding it, this latter giving the gravitational attraction." Grounds are then adduced for holding that (6) "Gravitational force is propagated at practically infinite velocity as an expansional wave."

E. H. B.

21. *Action and Range of Molecular Forces.* **W. Müller-Erzbach.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 9–27, Jan.–March, 1900.)—In continuation of the investigation referred to in Abstract No. 774 (1899) the diffusive action of CS_2 through gum-covered paper, collodion, &c., into free air is observed, and then the effect of slabs of fir, sealing-wax, beeswax, and indiarubber (which easily absorb CS_2) is examined when they are immersed in CS_2 with one face protected by impermeable glass, and the other covered by these permeable coatings; and it is found that in the latter case the rate of passage of CS_2 through these coatings is much (even over ten times) greater than in the former. The author's chief conclusions are that (i) CS_2 penetrates by free diffusion into colloidal bodies to only small depths, (ii) when by free diffusion CS_2 has reached an attracting body, its flow becomes perceptible though before not observable, (iii) different attracting bodies have different attractive actions on CS_2, beeswax attracting less than either fir or indiarubber, (iv) the attractive effect is perceptible through a distance of at least 0·066 mm.

R. E. B.

22. *Motion of a Sphere in a Viscous Fluid.* **H. S. Allen.** (Phil. Mag. 50. pp. 323–338, Sept., and pp. 519–536, Nov., 1900.)—This paper describes an experimental investigation of the rate of motion of bubbles of gas in rising through a viscous liquid. A bubble of air is liberated from a fine capillary tube at the bottom of a long glass vessel containing the viscous liquid, and the time taken for the bubble to rise through certain heights is measured. The bubble is caught under a small glass vessel before it reaches the surface, and its diameter is then measured by means of a microscope. All the data are thus obtained for determining the connection between the limiting uniform velocities of the bubbles and their diameters. The object of the investigation was to see whether this connection conforms with the theoretical one for the motion of a solid sphere. According to the theory, $V a$ must be small compared with ν, the kinematic coefficient of viscosity, in order that the motion be non-eddying, a being the radius. If this condition is fulfilled, then the velocity

varies as the square of the radius. If, however, the motion is eddying, a study of the dimensional equation shows that the velocity is proportional to

$$a^{\frac{8}{n}-1} \Big/ \nu^{\frac{2}{n}-1}$$

if we assume that the resistance is proportional to V^n.

In order that the motion may be non-eddying, the radius a, when water is used, must be very small, so small that it approaches the lowest practical limit of size of the bubble. The experiments with water are therefore all on eddying motion. The curve obtained by plotting V with a as abscissæ is a straight line, so that the resistance must therefore be proportional to $V^{3/2}$. By using aniline the critical radius is increased greatly, and the experimental results with this liquid show that with the smallest bubbles $V \propto a^2$ so long as the motion is non-eddying, and $V \propto a$ in the case of eddying motion. Experiments were also made with paraffin and amber spheres.

The terminal velocity acquired in the case of eddying motion is given by the following formula :—

$$V = k \left(\frac{\rho - \sigma}{\rho} . g \right)^{\frac{2}{3}} \frac{a - ha'}{\nu^{1/3}}, \qquad (1)$$

where the value of the constant k is nearly $\frac{1}{2}$ and of h nearly $\frac{2}{3}$, a' being the critical radius given by $Va' = \nu$, ρ being the density of the liquid and σ that of the sphere.

In the second part of the paper the experiments are extended to the case of a body whose terminal velocity in falling through the liquid is great. Steel balls of various diameters (0·3 to 0·8 cm.) are allowed to fall through water, the ball being liberated under the surface of the water. The velocity of the ball is determined by a photographic method, the ball being instantaneously photographed at equal intervals of time on the same plate, the plate being moved laterally between two exposures, so that a fresh strip is exposed for each photograph.

In every case, except that of the largest ball, the terminal velocity agrees with the law of resistance

$$R = k\rho a^2 V^2,$$

where a is the radius of the sphere and ρ the density. The discrepancy in the case of the largest ball is attributable to the influence of the sides of the vessel, since by increasing the size of the vessel the discrepancy is greatly diminished. All the terminal velocities are over 80 cm./sec. (83 to 128 cm./sec.), and the rate at which the acceleration falls off was observed to increase suddenly when the velocity was about 75 cm./sec. This seemed to show that the law of resistance to the *steady* motion of the sphere undergoes a sudden change at this particular velocity.

The terminal velocity is given by

$$V^2 = \frac{1}{k} \cdot \frac{4}{3} \pi g \frac{\sigma - \rho}{\rho} a, \qquad (2)$$

where σ and ρ are the densities of the ball and liquid respectively. The mean value of k is $5{\cdot}50 \times 10^{-4}$.

The conclusions derived from all the experiments are as follows :—

(1) When the velocity is sufficiently small the motion agrees with that deduced theoretically by Stokes for non-sinuous motion, on the assumption that no slipping occurs at the boundary. In such motion the resistance is proportional to the velocity.

(2) When the velocity is greater than a definite critical value the terminal velocity of small bubbles and solid spheres is proportional to the radius less a small constant; it may be expressed by the formula (1), which indicates a resistance varying as the velocity raised to the power three halves.

(3) For velocities considerably greater than those just considered the law of resistance is that which Newton deduced from his experiments, namely, that the resistance is proportional to the square of the velocity. J. B. H.

23. *Graphical Treatment of Experimental Curves.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 35. pp. 96–97, Oct. 5, 1900.)—The author has had occasion to integrate an expression of the form—

$$z = \int \phi(x) f(x)\, dx,$$

where $f(x)$ is given by an experimental curve. By partial integration he obtains

$$z = [\phi(x) f(x)] - \int \phi'(x) f(x)\, dx,$$

an expression which can be dealt with graphically, since all the factors in it are known. J. B. H.

24. *Rainfall, Character of Seasons, and Drought Curves.* **H. Deane.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 63–68, 1900.)—As the usual methods of plotting rainfall do not give any information concerning the conditions of the soil, the author proposes a new way of plotting drought curves. The upper line is the soil saturation curve. The drought line underneath it represents the amount of rain (in tenths of an inch) required to restore saturation for that day. Any excess of rain over that saturation could not be plotted, but only be entered in figures. Evaporation begins with cessation of the rainfall, and it will depend upon temperature, wind, &c. The average monthly rates of evaporation from water have been tabulated by H. C. Russell. The author takes half these rates as the "rates at which evaporation from the soil would probably begin." The diagrams given by the author are based upon his own rainfall record for the Paramatta River district, covering the years 1883 to 1899. H. B.

25. *Determination of Drought Intensity.* **G. H. Knibbs.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 69–85, 1900.)—Observations, partly mathematical, on the preceding paper. The real condition of the soil will depend upon a great many factors, independent of one another; upon the quantity and rate of rainfall; slope, relative saturation and permeability of the soil; percolation through it, when interstices are filled or not filled with water; temperature, solar radiation, humidity, diffusion of vapour, wind, deposition of dew; further, upon the mechanical effects of frost, and finally upon biological factors, vegetation, &c., which we cannot express mathematically at all. Yet the possible observations would be of great service for estimating the drought intensity. H. B.

26. *Heat and Thunderstorm after Dark.* **H. C. Kiddle.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 204–206, 1900.)—Observed at Seven Oaks, on the Macleay River, N. S. Wales, seven miles from the sea. Hot weather had prevailed for several days, the maximum being reached already at 10 a.m., the heat being as strong at 7.30 a.m. as at noon; a north-easterly breeze from the sea then cooled the air. The maximum reading of November 27, 1899, about

10 a.m. was 91·8° ; at 7 p.m. it was 75°. Lightning without rain then approached from W.N.W. with a hot wave ; in a few minutes the temperature rose to 86° ; at 8.15 p.m., when the disturbance had passed, it was 95·5°. H. B.

27. *Hydrogen and Hydrocarbons in the Atmosphere.* **A. Gautier.** (Revue Scientif. 14. pp. 389–399, Sept. 29, 1900 , Comptes Rendus, 131. pp. 647–652, Oct. 22, 1900. Paper read before the International Congress of Pure Chemistry.)—The author describes his combustion apparatus for determining the combustible gases, essentially H_2 and CH_4, in the atmosphere. The determination is very difficult because at the high dilution of these gases, with up to 20,000 times their volumes of air, the combustion of hydrogen is never complete, and the carbon burns at a slower rate than the hydrogen. As both gases are determined together, their percentages can only be estimated statistically from the proportions of the resulting H_2O and CO_2. From many experiments, often lasting twenty-four hours each, conducted in Paris, in an oak forest, in a desolate part of the Pyrenees at an altitude of 2,785 m., and on a rock 40 km. from the north coast of Brittany, the author concludes that the purest (ocean) air contains normally about 20 cc. of H_2 in 100 litres, *i.e.*, two parts in 10,000. The hydrocarbons, estimated as CH_4, amount to 22·6 cc. (in 100 l.) in Paris, 11·3 in the forest, 2·19 in the mountains, and zero out at sea. Further experiments yield for the Paris air : 19·4 cc. of H_2 (in 100 l.), 12 of CH_4, 1·7 of benzene and homologues, 0·2 of CO. Hydrogen exhalations are common in volcanic districts, and methane is exhaled by the soil. By decomposing granite with water at 300° C. or with diluted phosphoric acid at 150° C., the author found large volumes of hydrogen in the gases liberated, up to 400 cc. per kg. of granite in the latter case. It is not necessary, however, to assume the penetration of superficial water down to the igneous regions of the interior. The decomposition with water of iron nitride, occurring in the Etna lava, would also yield hydrogen, and the decomposition of certain carbides, such as Al_4C_3, would give methane. H. B.

28. *Apparatus for Recording Direction of Wind.* **W. Volkmann.** (Zeitschr. Instrumentenk. 20. pp. 237–239, Aug., 1900.)—At the Agricultural College of Berlin the apparatus registers eight wind directions with the aid of two styles. The electrical arrangements are of the Sprung type and combined with a Fuess vane. The current distributor is a platinum sector of 135°, turning about its vertical axis over four contacts, joined to two pairs of electromagnets, arranged in the same horizontal plane. In front of each pair swings an iron pendulum, to which a style is attached, and the two styles draw zigzag curves on a paper tape. Deflections of the pendulums to the left signify wind from the N. and E. respectively ; to the right, S. and W. ; the simultaneous play of the pendulums indicates N.E., &c. As continuous records are not desired, the return wire is taken to a relay, which is excited every three minutes by a clock which also pulls the tape down ; thus twenty records are obtained every hour. The apparatus works with weak currents of 0·01 ampere. The platinum sector is not exposed to shocks, nor does it impede the vane. The gearing is not explained. H. B.

29. *Hail Showers and Cannonades.* **J. Sigaux.** (Revue Scientif. 14. pp. 461–464, Oct. 13, 1900.)—The first congress concerning the dispersion of hail showers by cannonades was held at Casale in 1899. At present Italy is supposed to have 16,000 hail stations, chiefly for the protection of vineyards. At Denicé, in the Beaujolais district, fifty-two steel guns of the Vermorel type

mounted perpendicularly are used for this purpose. The storms approach almost always from the south-west, and the guns furthest out in that direction are discharged first, twice every minute, if possible, during the first minutes; the cannonade is continued even when hail falls until the storm has dispersed. The Government grants the powder at a reduced price. The author discusses the costs of such installations. The effect might depend upon the column of hot air blown upwards from the gun. H. B.

30. *Meteorological Kite-Flying.* **S. P. Fergusson.** (Science, 12. pp. 521–523, Oct. 5, 1900.)—The greatest height reached at the Blue Hill Observatory with a kite attached to a No. 17 steel pianoforte wire on July 19, 1900, was 4,850 m. The original Hargrave kites attained an angular altitude of 54° or 56°; the maximum angle is now 66°, and the downward pressure of the wind on the upper edges of the cells is not strong, as long as the wind velocity does not exceed 20 m. per second. Such steep kites are, however, unstable, and a slight pull on the line may bring them beyond the zenith. Thin wires are on the whole preferable to stout wires, but for the highest angular altitudes the stouter wires are safer, in spite of their greater weights. The reason is that the pressure of the wind on the wire is an essential factor; this pressure depends upon the surface, which increases less rapidly with increasing diameter than the weight. As a rule, six kites, three large and three small ones, of a total lifting surface of 30 sq. m., are employed at one time; for eight kites, No. 25 or 26 wire would be best suited. H. B.

31. *Annual Variation of Temperature at Melbourne.* **R. J. A. Barnard.** (Phil. Mag. 50. pp. 408–409, Oct., 1900.)—The author has analysed the temperature observations, extending over forty years, after Rijkevorsel's method. The forty years were divided into two groups, 1859–78, and 1879–98. In each group the average for each day is obtained and modified by replacing the temperature of each day by the mean of the five consecutive days of which the particular day is the centre. The results are plotted as curves. Some striking resemblances are noticeable, especially at the end of March. The temperature begins to drop rapidly in the second week of March, the secondary minimum in each group on the 19th being followed by a maximum on the 25th and 26th. But on the whole the spells of weather do not appear to be so well marked as in Europe, owing probably to the more uniform conditions of the southern hemisphere. The author regards the method as valuable, but would not draw any conclusions from periods of less than forty years with groups of twenty years. H. B.

32. *New Theory of the Milky Way.* **C. Easton.** (Astrophys. Journ. 12. pp. 136–158, Sept., 1900.)—Previous investigations by the author had indicated that the Milky Way had a roughly annular structure (Astrophys. Journ. 1. pp. 216–221, March, 1895). Seeliger, however, thinks that the stellar accumulations in the galaxy in different directions are probably at different distances. In the present paper the author renounces the "annular" theory and proposes a new conformation in its place. He first draws attention to the marked difference in brightness of the galaxy at the two diametrically opposite regions of VI and XVIII hours of right ascension respectively.

Gauges by Herschel, Celoria, and Houzeau give decisive evidence of the preponderance of bright regions in the zone near Aquila (XVIII h. RA.), and indicate that our solar system is probably *eccentrically* situated with respect to the galaxy. Exhaustive discussion follows of the many different peculiari-

ties, and finally it is proposed that the Milky Way be regarded as a special nebula of somewhat advanced development, the central condensation of which consists of the abnormal bright region near β and γ Cygni. Our solar system and possibly many of the brighter stars would constitute another smaller condensation away from the centre, and the various sections through the different spirals in all directions might serve to account for most of the appearances actually seen. C. P. B.

33. *Solar Phenomena and Anomalous Dispersion.* **W. H. Julius.** (Astrophys. Journ. 12. pp. 185–200, Oct., 1900. From the Roy. Acad. Sci. Amsterdam, Proc.)—The author considers the application of the phenomena of anomalous dispersion as determined by Becquerel in the case of the sodium (D) lines to the theory of Schmidt regarding the visible photosphere of the sun as an optical phenomenon produced by the curved refractions of the sun's atmosphere. In the actual experiment with sodium he describes an additional appearance to that figured by Becquerel, whose diagram would indicate that light was wanting in the region of the D lines themselves, but in the figures here given it is seen that this is only caused by the great lateral displacement of the distorted lines.

The chief inference from such data is that when light is emitted by a source yielding a continuous spectrum, and then traverses a space containing, for example, unequally distributed sodium vapours, the rays near the D lines will be more deflected than any others from their normal courses. The well-known "arrow-head" appearance of the bright chromospheric lines when observed with radial slit may be explained in this way. The characteristic phenomena connected with sunspots, spectra, the reversing layer and "flash' spectrum, and the displacement of the latter with respect to the Fraunhofer lines are also considered. C. P. B.

34. *Actinometry during Partial Solar Eclipse.* **S. R. Bennett.** (Roy. Dublin Soc., Proc. 9. pp. 365–376, Oct. 17, 1900.)—The chemical effect of the variation in the solar radiation during the eclipse of May 28, 1900, was measured by means of an actinometer depending on the change of tint of sensitised paper. Curves are given showing the observations made.
C. P. B.

35. *Temperature during Partial Solar Eclipse.* **C. Martin.** (Roy. Dublin Soc., Proc. 9. pp. 362–364, Oct. 17, 1900.)—This paper gives results obtained at the Dunsink Observatory during the partial eclipse of the sun on May 28, 1900. Two heat radiation thermometers were used, with white and black bulb respectively. These were mounted about 1 inch apart on a post 6 feet high, with the bulbs pointed directly to the sun. Curves are given showing the variations, from which it is seen that the temperature was at its lowest about ten minutes after mid eclipse. With the black bulb the highest reading was 63·7°, the lowest 35·7°, showing a fall of 28°; while with the white bulb the corresponding readings were 15·6° and 3°, showing a fall of 12·6°. C. P. B.

36. *Detection of Corona without an Eclipse.* **H. Deslandres.** (Comptes Rendus, 131. pp. 658–661, Oct. 22, 1900.)—The author describes his work during the recent total solar eclipse in May, 1900, when he states that he found distinct evidence of the special radiation of the corona by investigation of the infra-red region of the spectrum. Since the eclipse he has set up an

instrument at the Meudon Observatory, near Paris, with which he considers positive results have been obtained. The image of the sun is produced by a mirror of 0·30 metre aperture and 1·50 m. focus. The light from this is analysed by a slit spectroscope with crown prism. A Melloni or Rubens thermopile and Deprez-d'Arsonval galvanometer are then used to detect any radiation passing through the apparatus. He finds that at all hours of the day the sum of the deviations measured along the solar equator are greater than the sum of the corresponding deviations along a polar diameter. This would indicate that the difference was due to the radiation of the corona, and is in accordance with the present disposition of the coronal streamers at sunspot minimum—great equatorial extensions and small polar plumes.

C. P. B.

37. *Kinetic Theory of Planetary Atmospheres.* **G. H. Bryan.** (Roy. Soc., Proc. 66. pp. 335–336, June 9, 1900.)—After citing previous work by Waterson and Stoney [Abstracts Nos. 1025 (1898) and 1988 (1900)] the author investigates the conclusions obtained by applying the Boltzmann-Maxwell distribution to the atmospheres of planets. The advance on work done in 1893 consists in the consideration of the effects of axial rotation of the planets, the surfaces of equal density then becoming of the form originally suggested by Roche. These cease to be closed surfaces when passing to the outside of the point on the equatorial plane, where the centrifugal force just balances planetary attraction. The author calls the surface through this point the "*critical surface*," and the ratio of density at planet's surface to the density at this critical surface, the "*critical density ratio*." He then calculates the logarithm of this quantity for particular gases at different temperatures on the various planets. Next the rate of flow outwards from this surface is determined, and instances cited of the values deduced for helium, hydrogen, and water-vapour, which would appear to indicate that helium cannot escape from the earth's atmosphere at existing temperatures, nor water-vapour from the atmosphere of Mars. C. P. B.

REFERENCES.

38. *Experiment on Gas Pressure.* **C. Forch.** (Phys. Zeitschr. 1. pp. 574–575, Sept. 15, 1900.)—A lecture experiment modified from one of Warburg's so as to allow any gas to be used, the object being to show the dependence of gaseous pressure on the height and density of the gas column. G. E. A.

39. *Crystal-Elasticity.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 117–176, 1900. Referat f. d. internationalen phys. Congress in Paris.)—An account of the present-day state of our knowledge of crystal-elasticity. T. H. P.

40. *Testing of Aneroids.* **P. Hebe.** (Zeitschr. Instrumentenk. 20. pp. 253–266, Sept., 1900.)—Paper on the methods adopted at the Charlottenburg Imperial Physico-Technical Institute during the past ten years. A. D.

41. *Magnetic Influence of Sun on Earth and Comets.* **A. Harvey.** (Canadian Inst. Toronto, Trans. 6. pp. 345–358, 1899.)—The paper is a discussion of the simultaneous occurrence of outbursts of spots on the sun, magnetic disturbances and auroræ on the earth, and peculiarities in the features of comets. The probability of the suggested close connection is supported by the curves given from automatic records of the horizontal force at times when specially prominent spots were existent. C. P .B

LIGHT.

42. *Velocity of Light.* **Perrotin.** (Comptes Rendus, 131. pp. 731–734, Nov. 5, 1900.)—Operations have been commenced at the Observatory of Nice in view of a new determination of the velocity of light. The method adopted is that of the toothed wheel of Fizeau as modified by Cornu. The results of the preliminary observations between two stations nearly 12 kilometres apart are here given. The value found is $299{\cdot}90 \pm 0{\cdot}08$ for the velocity *in vacuo* expressed in thousands of kilometres. This number results from about 1,500 measurements extending over a year, the observers having made use only of images absolutely still, and taken the observations at leisure and without precipitation, with the object of attenuating or eliminating systematic errors, especially those of a physiological order. The source of light was the filament of an electric lamp of 16 candle-power.

J. J. S.

43. *Abnormal Wave-Velocity near a Focus.* **P. Zeeman.** (Phys. Zeitschr. 1. pp. 542–543, Sept. 1, 1900.)—Gouy has shown that when monochromatic light passes through a focus or a focal line its path appears to be shortened by a half wave-length or a quarter wave-length respectively. The present paper shows that this is due to an increase of velocity of propagation near the focus. The mathematical theory establishing this begins with Hertz's electromagnetic doublet, and treats it by the Hertz-Heaviside equations. It is thus derived that the *phase-velocity* is infinite at the doublet, and falls to the usual speed of light at distances from it which are great compared with the wave-length. An experimental demonstration of the abnormal speed is then described. It consists essentially of a plano-convex lens of calcspar, with its optical axis in the plane face, placed between two Nicol prisms. All are mounted on an optical bank, illuminated, and the resulting system of interference rings observed. On exploring in the neighbourhood of the foci for ordinary and extraordinary rays, the evidence of the abnormal velocity can be observed.

E. H. B.

44. *Rangefinders.* **W. Stroud.** (Nature, 62. pp. 607–609, Oct. 18, 1900. Paper read before the British Association.)—This paper contains a synopsis of a lecture on Rangefinding delivered at the British Association meeting at Bradford. After dealing with the general principles of rangefinding, the author shows how the operation of finding the range, which is comparatively easy on land when length of base and time are not restricted, becomes at sea a most interesting and difficult scientific problem owing to the limitation of both base and time. He then describes four instruments, all of which are used, or promise to be used, for warlike purposes. These are: (1) The Watkin Mekometer, which is used by infantry. (2) The Watkin Depression Rangefinder, used at certain stations for coast defence. (3) The Grousillier-Zeiss Rangefinder. (4) The Barr and Stroud Rangefinder, used in the British and other navies, in coast fortifications, and to some extent in the field.

The mekometer is a long-base two-observer rangefinder, one observer carrying a box sextant and the other an optical square, the two observers being kept at a constant distance apart by a cord between them. The Depression Rangefinder consists of an instrument of the type of a sur-

veyor's level, which is used for measuring the depression of a ship's water-line below the horizontal plane through the observing station, which is generally a fortress on a hill near the coast. A correction has, of course, to be made for the height of the tide. The Grousillier-Zeiss Rangefinder has already been described in these pages [Abstract No. 1396 (1900)]. The Barr and Stroud Rangefinder is not described in the paper, but the reader is referred to the Transactions of the Institute of Mechanical Engineers, 1896, or to *Engineering*, 1896, vol. i. p. 233. Illustrations of the Barr and Stroud Naval, Fortress and Field rangefinders, and of the fields of view of the Grousillier-Zeiss instrument are given. J. B. H.

45. *Illumination of Objects under the Microscope.* **R. W. Wood.** (Phil. Mag. 50. pp. 347–349, Sept., 1900. Paper read before the Physical Society of London.)—Toepler's "Schleieren-Methode" is here used to render visible under the microscope the separation of two bodies of nearly equal refractive index, the one immersed in the other, as, for instance, glass particles immersed in cedar oil, or the different crystals in a rock section. A low-power objective is used in the microscope, and a short focus lens is placed under the stage so as to form an image of the lamp (placed a few feet away) at a point between the object to be examined and the objective. A screen bounded by a straight edge is placed in front of the flame so as to cut off half the flame. At the image of this screen formed in front of the objective by the short focus lens, a small straight edge is interposed with its edge parallel to the straight edge of the image of the screen, and in such a position as to cut off all the light except a very fine slit between the two edges.

Two photographs are shown of glass particles in cedar oil, one taken with ordinary illumination and the other with the above arrangement. The difference is very marked. J. B. H.

46. *Index of Refraction and Dispersion of Bromine.* **C. Rivière.** (Comptes Rendus, 131. pp. 671–672, Oct. 22, 1900.)—The index of refraction of bromine for wave-lengths ranging from 790·9 to 539 was determined at 10°, 15°, 20°, and 25°; the results are given in tabular form. The dispersion is unusually high, the value 0·037 being found at 20° between the A and D lines. N. L.

47. *Dispersion of Iceland Spar.* **E. Carvallo.** (Journ. de Physique, 9. pp. 465–479, Sept., 1900.)—The author has made a new experimental study of the dispersion of Iceland spar in the ultra-violet. It is more precise than former observations. On joining with it the one made formerly in the infra-red and the visible portion, a series is furnished the precision of which attains the fifth decimal figure of the index throughout the whole extent of the spectrum.

The author has calculated for the extraordinary ray two formulæ of dispersion with five terms—

$$\text{(I)} \qquad \frac{1}{n^2} = c'l^4 + cl^2 + a + bl^{-2} + b'l^{-4},$$

$$\text{(II)} \qquad n^2 = C'\lambda^4 + C\lambda^2 + A + \frac{b_1}{\lambda^2 - \lambda_1^2},$$

Where n represents the index of refraction; λ the wave-length *in vacuo*; and $l = \frac{\lambda}{n}$, the wave-length in the body studied for the same radiation. Both formulæ represent the observations satisfactorily. For the ordinary ray

neither of these two formulæ with five coefficients is sufficient, but the first agrees more nearly with the facts than the second.

It is necessary to add a term in l^{-6} to formula (I) in order to represent the dispersion throughout the whole extent of the spectrum. The author has calculated the formula with six coefficients—

$$\frac{1}{n^2} = c'l^4 + cl^2 + a + bl^{-2} + b'l^{-4} + b''l^{-6}.$$

This also proved satisfactory.

In formula (II) it is necessary to take not only one fraction but two fractions—

$$\frac{b_1}{\lambda^2 - \lambda_1^2} + \frac{b_2}{\lambda^2 - \lambda_2^2}$$

For the ray Cd_{26} ($\lambda = 0{\cdot}214439\mu$), the term bl^{-2} is $-0{\cdot}044157$ for the extraordinary ray and 0·074016 for the ordinary ray. Consequently the success of the comparison of formula (I) with the observed numbers requires that more than four figures be known in the value of λ. The present work proves that the numbers determined by Kayser and Runge satisfy this condition. Their agreement with the numbers of Eder and Valenta tends to the conclusion that the fifth figure is exact. J. J. S.

48. *Colour Photography.* **E. S. Shepherd.** (Soc. Arts, Journ. 48. pp. 758–766, Aug. 31; 769–776, Sept. 7; 781–788, Sept. 14; and 793–797, Sept. 21, 1900. Cantor Lecture.)—Lecture I. is a popular demonstration of the principal optical phenomena.

Lecture II. treats of the spectrum, and the preparation of orthochromatic photographic plates. The construction and testing of the Cadett lights filters is described at length; these are for use with the Cadett Lightning spectrum plate, and are made in two types, the "Absolutus" and the "Gilvus." The former reduces the action of the blue so as to allow the reds and greens to impress the plate correctly, and requires an increase of exposure of about forty times; the latter increases it only five times, but leaves the reds uncorrected.

Lecture III. is occupied with a detailed description of the three-colour process of producing transparencies or prints in natural colours, and Lecture IV. treats of typographic reproduction. G. H. B.

49. *Testing Photographic Shutters.* **R. Nerrlich.** (Zeitschr. Instrumentenk. 20. pp. 269–275, Sept., 1900.)—Apparatus and methods are described. A simple drop shutter with circular aperture gives an effective exposure equivalent to an actual exposure with full aperture equal to 0·43 × the time of passing of the aperture. A Goerz sector shutter working at $\frac{1}{150}$ second gives an exposure equivalent to $\frac{1}{250}$ second full aperture; at $\frac{1}{2}$ second it gives very nearly the full value. A focal plane shutter gives very nearly the full instantaneous value of equivalent exposure; but the speeds are not uniform throughout. A. D.

50. *Flame Measurer for Hefner Lamp.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 2. 10. pp. 108–109, 1900.)—This is a contrivance for easily measuring the height of the flame of a Hefner standard lamp. It consists of a rectangular glass prism, the hypotenuse of which has been given a spherical form, so that the whole acts like a cemented combination of a prism and plano-convex lens. When this is held near a light source, an

inverted image of the source is formed near the original, and the distance between the bases of the flame and its image when the tips apparently coincide will be double the required height. C. P. B.

51. *Photometry.* **J. Violle.** (Écl. Électr. 24. pp. 420–431, Sept. 15, 1900. Paper read at the Paris International Electrical Congress. An Abstract of this appeared in the Electrician, Sept. 28, 1900.)—This paper gives an account of the various photometric standards.

I. *Incandescence Standards.* (1) The platinum international standard gives satisfactory results provided the materials used are pure. Petavel gives the preference to the Violle standard, used under the following conditions :—

(*a*) The platinum must be chemically pure.

(*b*) The crucible must be made of pure lime.

(*c*) The hydrogen burnt must not contain hydrocarbons.

(*d*) The gases should be in the proportion of 4 volumes of hydrogen to 3 of oxygen.

The best mixture is obtained by sending the oxygen at the same time through an interior tube and through an annular conduit exterior to the hydrogen conduit. Under these conditions the platinum is raised to a temperature little higher than that of fusion and the brightness of the metal is not modified by a combination with carbon.

The following table gives the variation of the luminous intensity with the time expressed in seconds measured from the moment of stopping the arrival of the gases :—

Time.	Intensity.	Time.	Intensity.
10	2·236	90	1·001
20	1·503	100	0·993
30	1·196	110	0·991
40	0·908	120	0·988
50	0·693	130	0·986
60	0·623	140	0·984
70	0·559	150	0·897
80	1·008	160	0·722

The intensity falls at first very rapidly, then rises suddenly (when solidification occurs), and for the next 40 or 50 seconds varies very slowly, then the diminution becomes more rapid. It is considered that the uncertainty relatively to the intensity of the light emitted by the melted platinum under normal conditions does not exceed 1 per cent.

(2) Lummer and Kurlbaum have proposed to employ incandescent platinum at a lower temperature than that of fusion and defined by the condition that $\frac{9}{10}$ of the energy radiated should be absorbed by a layer of water 2 cm. thick ; but the most serious objection to this is that the temperature chosen is too low and the light emitted is too red. This arrangement might, however, be used as an intermediate standard.

(3) Experiments have been made with a view to taking the crater of the positive carbon in the electric arc as a standard. A difficulty in this case arises from the fact that when the arc hisses the most brilliant part displaces itself periodically over the surface of the carbon. Entirely satisfactory results have not yet been obtained.

(4) Incandescence lamps have been introduced as intermediate standards in photometry. In order that the luminous intensity may be constant, very precise regulation of the potential at the terminals is necessary. When the

mean of the intensities in three directions is taken for the horizontal intensity, the mean error is about 2 per cent.

II. *Flame Standards.* (1) The Hefner standard, which uses amyl acetate and requires very careful regulation of the height of the flame, is the legal standard in Germany. Liebenthal has shown that its intensity is on the average many hundredths greater in winter than in summer. This effect is due principally to the presence of water-vapour. The influence of external pressure is feeble. The effect of carbonic acid is for equal volumes much greater than that of water-vapour. The diminution of the proportion of oxygen in the air after the lamp has been burning some time also affects it. Making corrections for these influences the Hefner standard becomes perfectly comparable with itself. Even then it cannot be considered perfect. The red tint of the flame and its feeble luminous intensity are grave faults.

(2) In the pentane standard of one candle, the liquid pentane contained in the receiver vaporises itself by a wick placed in the interior of a tube, which extends beyond it some centimetres. The vapours are inflamed on going out from the tube in such a way that the wick is not carbonised. The upper part of the flame is surrounded by a chimney which diminshes its mobility, and making combustion more active, renders the flame whiter. The height of the flame must be kept constant. The intensity of the visible part between the burner and the base of the chimney is then equal to an English candle.

In the lamp of ten candles, which is the regulation pattern for gas trials in England, the lamp is fed by a current of air charged with pentane vapour in its passage across a saturator; the mixture descends under the action of its own weight by a caoutchouc tube into an annular burner of steatite; the chimney is surrounded by a tube of brass in which is produced an ascending current of air led to the base of the ring of steatite. The height of the visible part of the flame must be 47 mm. According to Vernon-Harcourt, the ratio of the two standards does not vary by 1 per cent.

Liebenthal, on examining the one-candle pentane standard, finds that exact regulation of the flame is necessary, and that observations must not be made till the end of half an hour, as during this time the flame increases in height. Calculation shows that the efficacious distance in photometric measurements with such a lamp is that from the photometer to the axis of the lamp, diminished by half the radius of the tubes which limit the efficacious part of the flame. This lamp excels the Hefner lamp in having a more vigorous flame, but requires more attentive regulation. The influence of humidity is the same as in the Hefner lamp. It is affected by pressure: a change of 40 mm. produces a variation of 2 per cent. Liebenthal concludes that it is necessary with this standard to take into account the altitude of the place of observation. This appears to be the gravest fault of the pentane lamp and is considered to establish the superiority of the Hefner lamp as compared with it.

(3) The apparatus of Dibdin, which had been recommended by the Report of the Photometric Committee, was studied by Grafton. In it the air is carburetted by passing over pentane in a reservoir, which forms the base of the apparatus, and the proportion of air and of pentane depends on the temperature of the room. The degree of humidity must also have a great influence. In the Methven standard, on the other hand, with a diaphragmed flame, carburetted with pentane and fed by ordinary illuminating gas, very good results have been obtained. Humidity and temperature appear not to produce variations greater than 0·5 per cent., but this figure should not be accepted without reserve.

(4) Various flame standards have been lately proposed, which have not yet been adopted in practice. These are principally acetylene standards. The acetylene flame has a remarkable whiteness; the spectrophotometric study has shown that over the whole extent of the visible spectrum the light from acetylene differs little from that given out by melted platinum.

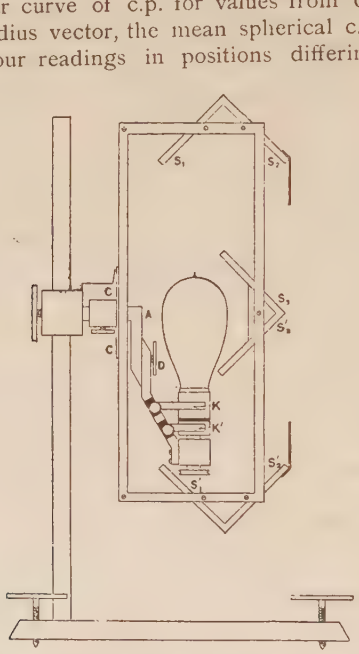
(5) A bolometric study by Clayton, Sharp, and Turnbull, has revealed the existence of unexpectedly large variations in the total emission of the different standards. In the English candle the variations may attain 46·5 per cent. of the mean intensity; the maximum variation for the German candle is 24 per cent. The variations of the Hefner standard may reach 22·6 per cent., but they are mostly due to changes of the height of the flame and may be reduced to 2 per cent. by careful regulation. The Carcel lamp may have extreme variations of 18·2 per cent., but the changes are slow and the variation may remain for 35 minutes inferior to 0·8 per cent. The authors conclude that the Carcel lamp is the most constant of the standards they have examined.

The paper next goes on to describe the arrangements of various recent forms of photometer, including Lummer and Brodhun's improved modification of Bunsen's photometer, the universal photometer of Blondel and Broca, the photomesometer and lumen-meter of Blondel, and Lummer and Brodhun's spectrophotometer. J. J. S.

52. *Luminosity of Coloured Surfaces.* **W. de W. Abney.** (Roy. Soc., Proc. 67. pp. 118–122, Oct. 26, 1900.)—If two yellow discs are taken, one (say) 6 inches in diameter and the other 4 inches, and between them is sandwiched a pair of interlaced black and white discs of 6 inches diameter, and the four discs are rotated on a rotating machine at a speed which will make the black and white into grey without scintillation, this grey can be made, by altering the proportion of black to white, to match the luminosity of the yellow. A very exact match can be obtained by observing the discs through a black transparent medium, such as the black obtained on a photographic plate after development with methol or amidol developers. The deposit may be so dense that the yellow colour may practically disappear, and the two dull greys may then be readily matched. The luminosity of the yellow in terms of the white is given by the angle which the white subtends when the small proportion of white reflected from the black annulus is added to it. The same procedure may be adopted for a green colour and its luminosity be obtained. When the luminosities of these two colours have been determined, 4-inch discs of them may be interlaced with blue, and a grey formed which can be matched with a grey formed of black and white as before. From the angles which the sectors of the colours subtend and of the black and white employed, the luminosity of the blue can be calculated. The luminosity of the blue being ascertained, a red disc may be interlaced with the green and the blue disc, and that of the red calculated. As a check a black and yellow disc may be interlaced and compared with the colour given with the red and green discs interlaced, one of the pairs being of greater diameter than the other.

Having obtained the luminosity of the three standard colours, that of any other colour can be calculated by substituting for one of them a disc of such colour, and again making a grey and matching it with a grey formed by the black and white. This method can be carried out in any light, but the luminosities of the colours will vary according to the quality and kind of light employed. J. J. S.

53. *Glow Lamp Support for Photometers.* **C. H. Sharp.** (Phys. Rev. 11, pp. 181–187, Sept. 1900.)—This support is designed for the determination of the mean spherical candle-power of a glow lamp from a few measurements. The lamp is supported with its axis vertical and is rotated about this axis. The lamp is not viewed directly, but after triple reflections in the mirrors S_1, S_2 and S_3, also S'_1, S'_2, S'_3. The frame carrying these mirrors can be rotated about the axis A, through an angle which may be read off on the scale C. By plotting the polar curve of c.p. for values from 0° to 90°, and determining the mean radius vector, the mean spherical c.p. is obtained. The author finds that four readings in positions differing by 30° are quite



sufficient, and he has obtained the following relative values for the mean spherical intensity with 4, 6, 7, and 10 readings :—

Width of Zones.	Number of Measurements.	Intensity.
30	4	0·868
18	6	0·863
15	7	0·864
10	10	0·8683

To determine the correcting factor for the reflection from the mirrors, the mean horizontal intensity is determined with the frame turned about A through 90° from the position shown in the diagram, and again by direct vision with the mirrors, S_3 and S'_3 removed. A photograph of the apparatus as made by Stoehorer and Sons, Leipzig, is shown in the paper. J. B. H

54. *Efficiency of Acetylene Flame.* **E. L. Nichols.** (Phys. Rev. 11, pp. 215–229, Oct., 1900. Paper read before the American Physical Society June 27, 1900.)—To determine the total efficiency of a flat flame produced from ordinary gas made by throwing calcium carbide on water, preliminary experiments were made to find the radiant efficiency, the heat c

combustion and the ratio of total heat generated to total radiation. Stewart and Hoxie, using an iron wire bolometer, find the value 0·105 for the radiant efficiency. Experiments show that an iodine cell absorbs 51 per cent. of the energy which passes through a water cell, and the value 0·207 being found for the ratio of the light energy transmitted through the water cell to the total energy reaching the bolometer when the cell is interposed, the radiant efficiency is thus found to be $0{\cdot}51 \times 0{\cdot}207 = 0{\cdot}105$. The heat of combustion as found by Rands with a Favre and Silbermann calorimeter is 10,000 calories. The method of determining the relation between the total heat generated in the flame and the heat dissipated in the form of radiation is described, the experiments being still in progress. Two values of the total efficiency as found by Ball are given, viz., 0·0236 and 0·0199, of which the former is the more reliable. G. E. A.

55. *Zeeman Effect.* **H. M. Reese.** (Astrophys. Journ. 12. pp. 120–135, Sept., 1900.)—The object of the investigation was to study the spectra of various elements in the magnetic field, and to determine the law of variation with the strength of the field. Curves were plotted with field strengths as abscissæ and separations as ordinates. In measuring the sextuplets, they were treated as quadruplets, the measurement of $\Delta\lambda$ being the distance between the two lateral components on one side and that of those on the other. In the case of the three zinc lines, the curve for the triplet is perfectly straight within experimental errors, except that it shows a slight tendency to droop at the highest field attainable as if the separation approached a limiting value. The curve for the quadruplet shows this tendency to a greater degree, and in that for the diffuse triplet it is quite pronounced, beginning at a field strength of 20,200 units. The other metals examined were cadmium, magnesium, iron, nickel, titanium, carbon, calcium, aluminium, silicon, and mercury. The following table gives some figures showing the dependence of the widening upon the field strength :—

Substance.	Line.	$\frac{\Delta\lambda}{H\lambda^2}$
Cadmium	4678·37	17×10^{-5}
Cadmium	4800·09	$15{\cdot}5 \times 10^{-5}$
Cadmium	5086·06	$10{\cdot}5 \times 10^{-5}$
Zinc	4680·38	17×10^{-5}
Zinc	4722·26	$15{\cdot}3 \times 10^{-5}$
Zinc	4810·71	$11{\cdot}3 \times 10^{-5}$
Magnesium	5167·55	$16{\cdot}7 \times 10^{-5}$
Magnesium	5172·87	$14{\cdot}9 \times 10^{-5}$
Magnesium	5183·84	$10{\cdot}5 \times 10^{-5}$

A few cases of dissymmetry are enumerated [see also Abstract No. 2158 (1900)]. E. E. F.

56. *Arc Spectrum of Iron.* **H. Kayser.** (Ann. d. Physik, 3. 2. pp. 195–203, Oct., 1900.)—Rowland's normal iron lines not being sufficiently numerous to give accurate interpolations, the author supplements them by some 300 additional lines, determined with a maximum error of 0·003 Ångstrom units. The lines are comprised within the limits of 2,300 and 4,500 Ångstrom units, and cover the extent of the usual photographic spectrum. E. E. F.

57. *Arc Spectra of Metals in Hydrogen.* **H. Crew.** (Astrophys. Journ. 12. pp. 167–175, Oct., 1900.)—The author was led to investigate the spectra of various metals by the hope that the altered conditions might have some influence on the grouping of the spectrum lines and that their classing into series might be facilitated. The general effect of hydrogen on the arc-spectrum is a marked diminution of intensity, in many cases to as much as one-hundredth the normal values. In addition to such a general effect, however, the important fact was noted that there was a selective action on certain lines only, some lines being intensified, others weakened or suppressed altogether. Many of these intensified lines are what have been previously considered only *spark* lines. Tables are given showing the lines affected in this manner in the spectra of magnesium, iron, and zinc. From these the author concludes :—

(1) That all lines in the arc-spectrum which are affected by hydrogen, whether enhanced or weakened in intensity, belongs also to the spark spectrum.

(2) The lines which are known to belong to Kayser and Runge's series are unaffected by the change from air to hydrogen. C. P. B.

58. *Photography of Ultra-red Rays.* **G. Meyer.** (Phys. Zeitschr. 2. pp. 6–7, Oct. 6, 1900. Paper read before the 72nd Naturforscherversammlung at Aachen.)—Infra-red photography has not been followed up, Abney's method of preparing plates being complex and not always successful. In Burbank's mode of preparing plates (Phil. Mag., 1878) the use of quinine is not essential, the results being the same without it. These plates may be developed in dilute glycin developer, cooled down by addition of ice. With a diffraction grating, a ray filter must be used, consisting of ruby glass. Glass in the spectrograph scatters red light and fogs the plates by a general diffusion combined with a solarising action of the infra-red rays (Abney) which is more marked the greater their wave-length ; it should therefore be avoided. But with a ruby ray filter absorbing all as far as D, the conjoined action of the diffused red and the infra-red produces positives in which the lines up to 1,200μ can be recognised. In cases of line spectra the disturbing effect of red light is insignificant, and in these cases glass lenses may be used. A. D.

59. *Spectra of Hydrogen and of Aqueous Vapour.* **J. Trowbridge.** (Phil. Mag. 50. pp. 338–347, Sept., 1900.)—An illustrated paper devoted to proving that the "white spectrum" of hydrogen, consisting of many widely distributed lines, is the true one, and that the "four-line spectrum" is due to aqueous vapour, and therefore, in the solar atmosphere and elsewhere indicates the presence of oxygen. Under powerful condenser discharges, H, N, or air all yield this spectrum, due to aqueous vapour liberated from the glass : aluminium electrodes also persistently yield various compounds of N, H, and O. Conclusions as to the temperature of the stars are misleading if based on conditions of pressure and temperature in glass vessels, as electrical dissociation is the most important factor. The white spectrum of H is developed by a steady current which should not exceed a certain strength. "X-ray phenomena, produced by a steady battery-current, strongly suggest an electrical theory of the origin of the sun's corona." S. R

60. *Infra-red Portion of the Solar Spectrum.* **S. P. Langley.** (Comptes Rendus, 131. pp. 734–736, Nov. 5, 1900.)—The author gives a brief summary of the results obtained during the last six years in the study of the infra-red part of the solar spectrum. He presented to the Academy the proofs of the

last official volume which terminates the series of researches commenced in 1881 on the summit of Mount Whitney in California, at a height of about 4,000 metres. Owing to improvements in methods and apparatus, especially in the bolometer, during the last six years, more than 400 lines have been added to those previously described, and their position has been fixed for the first time. In all about 600 lines are given in the tables of the volume referred to ; these lines belong to the infra-red part of the spectrum comprised between $\lambda = 1{\cdot}8\mu$ and $\lambda = 5{\cdot}3\mu$ and their observation has extended over eighteen years.

While the increased sensibility of the apparatus has caused the new lines discovered during the last three or four years to be much more numerous than those formerly observed, at the same time the precision and certainty of the results have increased. Each line has been the object of a separate study : it has been determined by the combination of six to twenty independent observations : all the determinations have been made by means of a delicate micrometric apparatus.

Another point to which the author calls attention relates to the comparative studies of the infra-red telluric spectra which have been made during all seasons during five years from 1895 to 1900. Systematic variations of the spectrum have been observed, which appear in relation with the changes proper to each season. These variations are small but quite distinct. Predictions of changes may be possible and in the future may be valuable to agriculture. The author commends observations of this order to the notice of meteorological observatories in different parts of the globe.

J. Janssen. (Comptes Rendus, 131. pp. 737–738, Nov. 5, 1900.)—Janssen calls the attention of physical astronomers and meteorologists to the interest of Langley's remarks on the modifications which occur in the infra-red part of the spectrum at different seasons of the year. He draws attention especially to the variations of the quantity of atmospheric ozone. This plays such a part in the phenomena which relate to life that its study is of peculiar importance. Spectral observations allow of inquiry into the condition of the high layers of the atmosphere. Such observations are carried out on Mont Blanc and have a great interest on account of the height of the station. To-day the *telluric rays* (whose existence was proved in 1862) permit not only of the recognition of the presence of bodies of the most different kind which can exist in our atmosphere, but are able also to show the most delicate variations in their quantity. J. J. S.

61. *Prism and Grating Spectroscopes.* **N. E. Dorsey.** (Astrophys. Journ. 12. pp. 164–165, Sept., 1900.)—Observations were made with the object of determining whether in the refraction of light it requires time for the medium to reach a steady state ; *i.e.*, whether a short train of waves is refracted in the same way as a long train of the same period. A plane grating spectroscope and a prism spectroscope with a long train of prisms were adjusted so that the spectrum of the same source could be examined in each instrument ; then the slit was adjusted so that when the source was continuous (*e.g.*, an arc lamp) the spectrum was as nearly as possible the same in both instruments ; then the arc was replaced by a very quick spark and the spectra again compared. If the initial disturbance is refracted differently from a continuous one, then in the second case the lines as seen in the prism instrument should be broadened or rendered hazy on one or both sides as compared with the same lines in the grating spectroscope.

A small plane grating and a two-story Grubb spectroscope with ten 60-degree prisms were used. The spark spectrum as given by the Grubb instru-

ment was very faint and the results were unsatisfactory; but not the slightest effect was seen. The total duration of the light from each spark was about 10^{-7} seconds as measured by a rotating mirror. While this is too short to give sufficient light, it is probably much too long to render visible the effect sought even under good conditions. On comparison it was found that for a continuous spectrum of moderate intensity the grating is in the red four, in the yellow five, in the green six, and in the blue eight times as efficient as the Grubb instrument: the efficiency being defined as the ratio of the product of the intensity of the spectrum by its width to the total amount of light striking the first prism or grating. J. J. S.

62. *New Spectrometer Slit.* **C. Fritsch.** (Phys. Zeitschr. 1. pp. 543–544, Sept. 1, 1900.)—The method is here recommended of removing some of the silvering from a mirror to produce a slit for a spectrometer and other similar instruments. An ordinary silver-on-glass mirror is used and fixed on the slide-rest of a lathe; a steel tool, whose point is of the width desired for the slit, is then pressed against the mirror while it is traversed along. The light freely traverses the glass where the silvering is removed, the silver left forming the opaque sides of this optical slit. A slit so made divided the D-line with a single crown-glass prism, and, when used with an Eder's quartz-spectrograph, yielded photographs of ultra-violet spark-spectra as sharp as those published by Eder himself. E. H. B.

63. *Becquerel Rays.* **M. Maier.** (Phys. Zeitschr. 2. pp. 33–34, Oct. 20, 1900.)—Experiments made with a Giesel preparation of radio-active barium chloride show that it possesses a great penetrating power. With an exposure of four minutes the rays passed through an iron plate 4 mm. thick and a layer of mercury almost 20 mm. thick. The rays from the barium, which is phosphorescent, are very diffusely reflected from various bodies, and no evidence could be found that they undergo regular reflection, refraction, or diffraction. G. E. A.

64. *Phosphorescence of Inorganic Compounds.* **E. Goldstein.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 38. pp. 818–828, July 26, 1900.)—The author employs the expedient of making the phosphorescent body move rapidly through a beam of kathode rays, so that any instantaneous phosphorescence is shown by the substance while still within the beam, and any subsequent luminescence is shown by the luminous tail visible on the substance after it has passed through. The substances are in the state of powder, so that the luminous effect is that of a cascade headed by the instantaneous luminescence, and of length proportional to the remanent luminosity. The author is driven to the conclusion that in the inorganic substances examined only the instantaneous luminescence is due to the substance itself, while the remanent luminosity is due to impurities. The apparently irregular character of the colourations is after all subject to definite rules, once the substances are carefully purified. One of these rules is that those metals which possess colourless oxides show a blue or violet instantaneous luminescence. Remanent luminescence may be produced by adding other metals in very small percentages, say 0·0001 per cent. Such small impurities cannot be detected by any chemical reaction, and the examination of the substances by kathode-ray luminescence therefore gives us a new and very delicate test for impurities. The positive light also produces luminescence under certain conditions. E. E. F.

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65. *Field of Reflecting Telescope.* **S. C. Reese.** (Astrophys. Journ. 12. pp. 219–227, Oct., 1900.)—A mathematical proof is here given of the fact that in a reflecting telescope there does not exist any field, plane or curved, on which the image of a star off the axis is either a sharp diffraction disc (either round or linear) or a single blurred circle. Very near the axis the distortion of the image is negligible. J. B. H.

66. *Zonal Aberration and Wave Surfaces.* **K. Strehl.** (Zeitschr. Instrumentenk. 20. pp. 266–269, Sept., 1900.)—Mathematical discussion and application to some particular microscopic and photographic lens-systems. A. D.

67. *Phosphorescence Produced by Radiation from Radium.* **H. Becquerel.** (Soc. Franç. Phys., Séances, 4. pp. 179–185, 1899.)—Paper similar to that referred to in Abstract No. 632 (1900).

68. *Becquerel Rays.* **O. M. Stewart.** (Phys. Rev. 11. pp. 155–175, Sept., 1900.)—A thorough, classified *résumé* of the work done on this subject, bringing up to date a former article [Abstract No. 1135 (1898).] G. E. A.

69. *Interferential Measures of Wave-Length.* **A. Pérot** and **C. Fabry.** (Comptes Rendus, 131. pp. 700–702, Oct. 29, 1900.)—The paper describes the method of directly measuring the absolute wave-length of any solar Fraunhöfer line by means of the interferential spectrometer. C. P. B.

70. *Spectra of Gaseous Mixtures.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 2. 10. pp. 110–112, 1900.)—The paper consists of comments on some recent work by Lewis [Abstracts Nos. 468 and 1793 (1900)] on the effects of certain gases when present as impurities in others on the spectra of the latter. C. P. B.

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71. *Law of Radiation.* **O. Lummer** and **E. Jahnke.** (Ann. d. Physik, 3. 2. pp. 283–297, Oct., 1900.)—Thiesen's equation for the energy of radiation as dependent upon temperature and wave-length states that for any given wave-length the energy increases indefinitely with the temperature, or in other words, that there is no limit to the amplitude of the vibration which gives rise to that particular ray. The same view is taken by Michelson, whereas W. Wien considers that with rising temperature the energy of every wave-length approaches a finite limit, such as in the case of sound would be prescribed by the breaking strength of the vibrating material. The authors have endeavoured to throw some light on this matter by obtaining a general formula from which the two contending formulæ could be deduced by altering the constants. The equation so obtained is—

$$E = cT^5(\lambda T)^{-\mu} e^{-\frac{c}{\lambda T}}.$$

Wien's equation is obtained from it by putting $\mu = 5$, Thiesen's by putting $\mu = 4{\cdot}5$, and Rayleigh's by putting $\mu = 4$. It is only in the first case that E may have a finite limit. Apart from the intrinsic improbability of just that case occurring, $\mu < 5$ is most in accordance with Maxwell's law of distribution; and if Lummer and Pringsheim's figures really represent the intensity of black radiation, the value $\mu = 4{\cdot}5$ is the only admissible one. E. E. F.

72. *Specific Heats of Alloys.* **E. van Aubel.** (Phys. Zeitschr. 1. pp. 452–453, July 21, 1900, and Journ. de Physique, 9. pp. 493–497, Sept., 1900.)—The theoretical importance of the possible reduction of specific heat with increasing temperature, known to occur in the case of mercury, and alleged to take place also in Arcet's and Lipowitz's alloys, studied by Spring, has led the author to inquire whether the values found by Spring by means of the cooling method are correct, and whether they are in agreement with Regnault's law of mixture. D. Mazzotto found for the specific heat of Lipowitz's bismuth-tin-lead-cadmium alloy a specific heat of 0·0354 between 5° and 50°, whereas Spring found it to be 0·0634 at 28°, 0·0554 at 50°, and 0·0625 at 90·5°. The theoretical value after Regnault is 0·03655, which agrees well with Mazzotto's value, but is considerably below the smallest of Spring's values. Similarly, the theoretical value for the specific heat of Arcet's bismuth-tin-lead alloy is considerably below Spring's experimental value. The author concludes that Spring's values are vitiated by the unsuitability of the cooling method for any but liquid substances, and that the alleged fall of specific heat with rising temperature does not occur. E. E. F.

73. *Limits of the Solid State, V.* **G. Tammann.** (Ann. d. Physik, 3. 2. pp. 161–194, Oct., 1900.)—If in one point of the equilibrium curve of two phases, of which one at least is crystallised, the volumes are equal, then the energies are different, and if the energies of both phases are equal, then the volumes differ. The second portion of this theorem having already been proved by the author's work on ice, it remained to prove the first portion. And this is now done by the author's experiments on benzol, naphthalene, phosphorus, and dimethylethyl carbinol. Compared with the volume changes

on the curve of fusion, the diminution of the heat of fusion is very small. This makes it very improbable that Δv and r (the heat of fusion) pass together through the value zero at any point of the fusion curve. In the case of dimethylethyl carbinol the volume change was followed up to within 10° of the point at which, by extrapolation, it should pass through zero. In a range of temperature of 40° the heat of fusion shows no sensible change. Should the heat of fusion and the volume change become zero together, that would involve a turn of the curves which is quite inconsistent with the known portions. The conditions for a critical point do not seem to exist. [See also Abstract No. 1659 (1900).] E. E. F.

74. *Constants of Diisopropyl and Diisobutyl.* **S. Young** and **E. C. Fortey.** (Chem. Soc., Journ. 77. and 78. pp. 1126–1144, Sept., 1900.)—In order to investigate further [see Abstract No. 79 (1900)] deviations from the generalisations of Van der Waals in the case of isomeric substances, the authors compared di*iso*propyl and di*iso*butyl with the corresponding normal paraffins. Specimens of these substances were prepared by the action of sodium on *iso*propyl iodide and *iso*butyl bromide respectively, in ethereal solution, and then carefully purified, in the former case the preparation being difficult and the yield very poor. It is remarkable that the di*iso*propyl was denser than normal hexane, whilst the known *iso*paraffins are invariably less dense than the corresponding normal hydrocarbons, and the di*iso*butyl was considerably less dense than normal octane. Another specimen of di*iso*propyl was therefore prepared by electrolysis of potassium *iso*butyrate, the gases evolved being absorbed in order to avoid loss. Under the best conditions 100 gms. of *iso*butyric acid gave only 1·5 gms. of moderately pure di*iso*propyl, the theoretical yield being 49 gms. The high specific gravity of di*iso*propyl was confirmed.

The boiling-points, vapour pressures, gramme and molecular volumes at various temperatures, critical volumes (by the method of Cailletet and Mathias corrected for slight curvature of the "diameter"), gramme and molecular volumes of the saturated vapours were determined from specimens prepared by the former of the above methods. Among other results the following were obtained :—

Di*iso*propyl	Boiling-point (760 mm.)	58·08°
	Specific gravity	0·67948
	Critical temperature	227·4°
	Critical pressure (mm.)	23345
	Critical volume (molecular in c.c.)	356·0
Di*iso*butyl	Boiling-point (760 mm.)	109·2°
	Specific gravity	0·71021
	Critical temperature	276·8°
	Critical pressure (mm.)	18650
	Critical volume (molecular in c.c.)	480·8

The absolute temperatures and molecular volumes of the two hydrocarbons, both as liquid and as saturated vapour, were read from the curves at the usual series of "reduced pressures." With few exceptions the ratios of (*a*) the absolute temperatures at any series of corresponding pressures to the absolute critical temperatures, (*c*) the volumes of saturated vapour to the critical volumes, (*d*) the actual to the theoretical densities at the critical

points, are higher for the normal paraffins than for their isomerides ; but the ratios (*b*) of the volumes of liquid to the critical volumes are lower for the normal paraffins than for the corresponding *iso*- or di*iso*-compounds. Comparing these results with those obtained for methyl butyrate and methyl *iso*butyrate, the authors regard the statements made in reference to *a*, *b*, *c*, as representing general laws, but the differences in the case of *d* as too small to allow of any definite conclusion being drawn. The double *iso*-group has generally about twice the effect of the single group, but the great irregularities in the case of di*iso*propyl show that something must be taken into account beyond the mere presence of the di*iso*-group. W. E. T.

75. *Constants of Normal Octane.* **S. Young.** (Chem. Soc., Journ. 77. and 78. pp. 1145–1151, Sept., 1900.)—The author made determinations for normal octane similar to those made for other paraffins [see preceding Abstract]. A specimen prepared from octyl iodide was very carefully purified. The vapour pressures were measured from 2 to 140 mm. by Ramsay and Young's method, from 160 mm. to atmospheric pressure with a modified distillation bulb provided with a reflux condenser, and for high temperatures with the pressure apparatus employed by the author in his previous researches. The differences between the calculated and observed pressures, as is the case with stannic chloride and acetic acid, which also have their critical temperatures higher than 280°, near the critical point were greater than with most substances examined. The author concludes that the boiling-point of bromonaphthalene had been estimated too low by Ramsay and himself, probably owing to their employing Regnault's values of the vapour pressures of mercury.

Among other results the following were obtained :—

Specific Gravity	0·71848
Boiling-point (760 mm.)	125·8°
Critical temperature.....	296·2°
Critical pressure	18730 mm.
Critical volume (molecular)	488·9 c.c.

The results obtained confirm previous conclusions that the ratios *a*, *d* (see preceding Abstract) increase, while the ratios *b* diminish with rise of molecular weight. W. E. T.

76. *Gas Thermometry.* **P. Chappuis.** (Phil. Mag. 50. pp. 433–442, Oct., 1900. Paper read before the Physical Society of London.)—The author tests an assumption made in a previous investigation [see Abstract No. 637 (1900)], viz., that the thermometric scale of a constant-volume nitrogen-thermometer with an initial pressure of less than 800 mm. of mercury agrees with the normal scale at high temperatures. He finds that the coefficient of dilatation of nitrogen diminishes gradually up to about 80°, and then increases very slightly ; probably it approaches a definite limiting value for each initial pressure, nitrogen at 100° behaving like hydrogen at ordinary temperatures, with a compressibility less than is required by Boyle's law. From 100° to 500° the pressures indicated by a constant-volume gas thermometer are a little too low, but the errors are small and of less account than other sources of uncertainty, even when the initial pressure is 1 metre of mercury. With lower initial pressures the divergences are probably diminished, and, with the thermometer previously employed, less than 0·04° for temperatures at the boiling-point of sulphur. The author attributes the difference between the value (445·2°) found by Harker and himself for this point, and that determined

by Callendar and Griffiths (444·53°), firstly to the fact that the scale of the constant-pressure nitrogen-thermometer differs more from the normal scale than does that of the constant-volume nitrogen-thermometer, secondly to the use by Callendar and Griffiths of too high a coefficient of expansion of air at constant pressure, and possibly to error in the coefficient of dilatation of the material of the gas-reservoir. He compares his own observations on the dilatation of porcelain, by Fizeau's method, with those of Bedford, who directly measured the distance between two marks on the porcelain tube by means of a comparator provided with two microscopes. In the latter case observations of the dilatation were made over the range of temperature for which the thermometer was to be employed, while in the former case extrapolation was necessary to an interval about four times as great as that in which observations were made. However, it is pointed out, that, as the marks on the tube were 8 mm. distant from the neutral plane, the mode of support of the tube exercised a considerable influence on the results obtained, and also that there might be sensible variations, as yet undetermined, in the elastic constants of porcelain at high temperatures. The hole in Bedford's tube was eccentric, variations of 2 to 4 mm. occurring in the thickness of its wall, and, as the porcelain and the glaze of the tube had slightly different coefficients of expansion, deformations probably occurred on heating. The author's observations on a specimen of the same tube point to a larger coefficient of expansion than that determined by Bedford, and indicate that the cause of this is an inequality in the dilatation of the two opposite sides of the tube, which necessarily involves a change in its form.

The paper concludes with a table of corrections applicable to the platinum thermometer scale, in which the sulphur boiling-point is assumed to be 444·53°, to transform it to the new scale, for which the sulphur boiling-point is 445·2°. W. E. T.

77. *Platinum Thermometry.* **C. Chree.** (Roy. Soc., Proc. 67. pp. 3–58, Oct. 3, 1900.)—An account is given of experiments conducted at Kew Observatory during the years 1895–1899 on the behaviour of seven platinum thermometers, of which six were certainly, and the seventh probably, constructed of the same sample of platinum wire. The original installation was described in *Nature*, Nov. 14, 1895. In the resistance-box at first used, which had a plug system of the ordinary Post Office pattern, it was found after a time that pulling out a plug influenced the tightness of its neighbours ; it was therefore improved by the introduction of a new system of plug-holders (fusible metal inside Doulton ware) in which the plug-holders were separately supported. The bridge wire was of platinum silver, having the same temperature coefficient as the coils ; a difference of reading of 1 cm. on it answered nearly to one box unit, or to a difference of temperature of 1° with all the thermometers but one ; it would have been desirable for 1 cm. on the bridge wire to have answered to not more than 0·1° C.

Excluding observational errors and defects, such as moisture in the tube surrounding the platinum wire, 17 causes of change in the readings or of error were examined. Changes in the relative resistances of the leads were found to occur, which led to errors at least of the order 0·01° or 0·02° unless special means of eliminating them were adopted. To guard against errors arising from *slow regular* changes in the relative resistances either of the leads or of the proportional arms frequent zero-point observations were necessary. Also frequent calibrations of the box coils, however laborious, could hardly be avoided in physical work of the highest accuracy. Uncertainty of the order

0·04° was found to arise owing to shift of the bridge centre. During a day's observations this was found to drift. Error owing to thermoelectric currents was diminished by putting in a padded box the Griffiths key employed, but it was still advisable to take readings with the current in opposite directions. Even with only one dry cell in use, considerable uncertainty was introduced, if 20 ohms were inserted in the battery circuit instead of 100 ohms; unless the heating effect of the current can be exactly ascertained and allowed for, the sensitiveness of the galvanometer used should be largely increased.

When a comparison is required between observations made on different days, and therefore the absolute values of the platinum resistances are required, error in the temperature coefficient of the coils is of importance. The author recommends that the entire room containing the apparatus should be kept at the standard temperature of the coils, and that one standard temperature should be adopted for summer, another for winter. It is also desirable that the bridge wire should be better protected than in the Kew box, and its temperature measured directly. The immersion of the thermometer should be for at least 10 cm. in addition to the length of the bulb; he suggests that owing to insufficient immersion the value of the melting-point of silver, as determined by Hugo and himself, was too low.

Platinum thermometers were found to be extremely *slow*, compared with mercury thermometers. The author thinks that appreciable error arises from the reduction of sulphur-point observations to standard barometric pressure, and arrives at the formula—

$$t = t_s + 0{\cdot}090\,(p - 760) + 0{\cdot}0002\,(p - 760)^2,$$

instead of Callendar's linear formula; further experiments on the question are desirable.

The resistances of the thermometers at the fixed points appear to have continued constant, except in the case of those exposed to high temperatures, such as the melting-point of silver. In one case two exposures to the sulphur-point and two to the temperature of molten silver produced a fall of approximately 0·7° in the zero-point. Differences occur between the temperatures recorded by the different thermometers. The phenomena presented are in the main the same as if the spirals consisted of given equal lengths of identical platinum, and in addition of variable lengths of a material, whose temperature coefficient is higher than platinum, and of which the resistances at the ice-, steam-, and sulphur-points are approximately as 1 : 1·6 : 3·6. The real nature of the underlying physical fact calls for further examination. Experiments are also desirable on the behaviour of *new* platinum thermometers, and on the effect of long or frequent exposures to very high and very low temperatures. W. E. T.

78. *Effect of Impurities in Platinum Thermometers.* **H. M. Tory.** (Phil. Mag. 50. pp. 421–432, Oct., 1900. Paper read before the Physical Society of London.)—The author gives an account of an investigation, the main purpose of which was to estimate the probable degree of accuracy attained in the determination of high temperatures by resistance thermometers constructed of commercial platinum wire. Five wires were compared over the range 400° C. to 1,000° C. Although they differed widely in purity the extreme variations of the temperatures observed, when calculated on the platinum scale by the formula—

$$pt = 100\,(R - R^\circ)/(R' - R_\circ),$$

R, R', R° being the observed resistances at the temperatures pt, 100° C,

and 0° C. respectively, were not more than 9° C. at 1,000° C. When the temperatures were reduced by the difference formula—

$$t - pt = dt(t - 100) / 10{,}000,$$

in which the difference coefficient d was calculated by assuming the boiling-point of sulphur, the variations at 1,000° C. were still from 5° C. to 10° C. If, however, the freezing-point of silver was employed to determine d, close agreement was obtained at high temperatures.

Curves are given, which show graphically that a linear relation, involving only two unknown quantities, connects the temperatures determined by each of the tested wires and the standard. The most consistent results for all the wires were obtained by reducing the observed values of pt by the linear relation and correcting the reduced values by the difference formula of the standard wire. This method would be inapplicable below 400° C., but it might be suitable for purposes of extrapolation. Heycock and Neville's method of reduction, by which the observed pt for any pyrometer is reduced to the normal scale by taking from a difference curve, drawn for the standard wire in terms of pt as abscissa, the corresponding $t - pt$ and increasing it in the ratio (d/d°) of the appropriate difference coefficient d to the standard d°, was found to give the best results for two of the wires, but not to apply well to the more impure specimens. The conclusion is drawn that from 0° C. up to the melting-point of gold, at least, a practical thermometric scale can be established at no point differing from the gas-thermometer scale by more than 2° C. or 3° C., and that observers working with platinum pyrometers can compare their results. The standard sample may be defined as a wire with a definite sulphur boiling-point and a definite silver melting-point. The author has not yet studied differences below 400° C. or above 1,000° C., but the linear difference curve appears to bend below 400° C. Such reduction as the above, however, is hardly necessary below 400° C., as for any good platinum wire the temperature there can be reduced directly by the difference formula, d being calculated from the sulphur boiling-point.

If the impurities in the platinum wire consisted of the baser metals no consistent results were obtained until the volatile constituents had been burnt out. No change of zero of importance was observed except one of the order of 1° C. after the first exposure to 1,000° C., which was probably due to impurities in the mica on which the wire was wound, or to the wire having been in a state of tension when wound. Drawing of the wire was found not to affect the indications of the standard wire, if both wires were properly annealed.

Callendar's method of comparison was adopted. The galvanometer used was specially designed by Callendar for resistance pyrometer work, with an astatic needle system in which the control is due to the passage of a current through a pair of coils at right angles to the galvanometer coils; the control current is proportional to that used in measuring the resistance, and therefore the deflexion due to a given difference of resistance is independent of the strength of the current. The deflexions could be read to $\frac{1}{100}$ of a degree. The pyrometers, enclosed in a porcelain tube, were heated in a bath of molten tin, the gas supply being regulated by a constant-pressure gas-regulator. To prevent oxidation the tin was covered with a layer of finely-ground arc-light carbon. Much difficulty was experienced owing to the action of the tin on the porcelain tubes. W. E. T.

79. *Gas Thermometer for High Temperatures.* II. **L. Holborn** and **A. L. Day.** (Amer. Journ. Sci. 10. pp. 171–206, Sept., 1900.)—For due correc-

tion of the readings of the thermometers investigated [see Abstract No. 86 (1900)] the expansibilities of the envelopes must be known. The linear expansibilities of rods of platin-iridium (80Pt, 20Ir), platinum, porcelain, and Jena glass 59^{III} were therefore measured : for PtIr

$$a = 8{\cdot}198 \times 10^{-6}, \quad b = 1{\cdot}418 \times 10^{-9},$$

in the formula

$$l/l_0 = 1 + at + bt^2,$$

and for Pt

$$a = 8{\cdot}889 \times 10^{-6}, \quad b = 1{\cdot}274 \times 10^{-9},$$

from 0° to 1,000° C. ; for porcelain

$$a = 2{\cdot}954 \times 10^{-6}, \quad b = 1{\cdot}125 \times 10^{-9},$$

from 250° to 625° and at 1,000°, these coefficients giving too large values outside the named ranges ; for the glass the results obtained varied with the way in which the glass was treated, but on the whole, $a = 1{\cdot}8 \times 10^{-5}$, and $b = 0$, up to 500° C.

The possible yielding of the walls of the envelope, temporary or permanent, when glowing and under the comparatively high pressure of the heated gas was examined, but was not found to occur with a PtIr bulb. Thorough comparisons with the gas thermometer were also made of the thermo-elements employed, and the following melting-points were determined :—

Cadmium	321·7	(320·7)	Silver (in air)...	955·0	(955·0)
Lead	326·9	(327·7)	„ (pure) ...	961·5	(960·7)
Zinc	419·0	(419·0)	Gold.....	1064·0	(1061·7)
Antimony	630·6	(629·5)	Copper (in air)	1064·9	
Aluminium ...	657·0	(654·5)	„ (pure)	1084·1	(1080·5)

The temperatures given in brackets are the melting-points found by Callendar and by Heycock and Neville with platinum resistance thermometers.

R. E. B.

80. *Thermodynamics.* **K. v. Wesendonck.** (Ann. d. Physik, 2. 4. pp. 746–756, Aug., 1900.)—The author discusses the question as to whether in Clausius's equation—

$$\int \frac{dQ}{T} \leqq 0,$$

the absolute temperature T is that of reservoirs of heat, or of parts of the bodies undergoing the cyclic process. The former alternative is implied by Kelvin's treatment. Poincaré puts the equation into the form—

$$\int\int \frac{dQ}{T} \leqq 0,$$

where the integration covers all the elements of the working system, and T is the temperature of an element. The author doubts however, whether this equation would hold good for great differences of temperature, though he believes that the temperature of the reservoirs of heat should not enter into the equation. Concerning the second law of thermodynamics, he is of opinion that it would be better not to found it entirely upon the doctrine of entropy, since it is not proved that in any system one state may be reached from another state along an irreversible path. Planck's treatment may fail to be conclusive when other work besides mechanical work is done by the cycle. If it were conclusive, it would lead to doubts concerning the general application of the principle of entropy.

E. E. F.

81. *Heat-Engine Diagrams.* **R. H. Thurston.** (Science, 12. p. 402, Sept. 14, 1900.)—In addition to two isothermals and two isentropics for gases on a pv-diagram it is convenient to draw two isopiestics and two isometrics to intersect the other lines outside the Carnot cycle which they form : for 17 different types of gas-engine, cycles are thus indicated on a single diagram. There may also be drawn on it two isothermals and two isentropics for a vapour, so as to illustrate a Rankine cycle as well. R. E. B.

82. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 34. pp. 312–377, July 31 ; and 683–700, Sept. 18, 1900.)—These papers are two more of a series of memoirs by Duhem, and are in great part based on his conclusions arrived at in the earlier ones, notably the last one [Abstract No. 1821 (1900)]. In that memoir the subject was treated principally from the theoretic point of view. In the present one he employs his formulæ (chap. ii. of the last memoir and elsewhere) to elucidate and reduce to system certain chemical phenomena and also certain phenomena observed in practical metallurgy. The first chapter treats of hardness (Härtung) as undergoing secular changes (a word introduced by C. Barus to express a process that may take years to become sensible), with two sub-sections on chemical changes, especially that of red phosphorus, and on the degree of hardness (Härtung) of a metal. The writer here considers a solid body of which each elementary part consists of a homogeneous mixture of two substances, α and β, either of which is capable of transformation into the other. The quantities of α and β per unit of volume are $1 - x$ and x respectively. The state of the body is completely defined by the chemical variable x, the specific volume v, and the temperature τ. An external pressure π is assumed. Finally it is assumed, with reference to the last memoir (chap. ii.) that x is affected by hysteresis, while v is free from it. Corresponding with the convention adopted in that chapter, α and β are to be so chosen as to satisfy the inequation—

$$\lambda(x, \pi, \tau) > 0.$$

The second chapter treats of alloys of iron and nickel. Following C. H. Guillaume [Abstract No. 1115 (1898)] the writer divides these into irreversible alloys, which contain less than 25 per cent. of nickel, and reversible if they contain more than that percentage. The third chapter deals with the overheating (Verbrennen) of metals, and the fourth with the forge. The whole is copiously illustrated by diagrams, which, however, could not be usefully reproduced in this Abstract.

The second of these two papers treats of certain methods of approximation by which a system depending on two variables, subject to hysteresis, may be investigated. The two variables, α, x, with the temperature τ for third variable correspond to a curve in space. If two such curves do not intersect, nevertheless their projections on one of the co-ordinate planes may intersect. Such intersections Duhem calls apparent intersections, and illustrates them by diagrams taken from Ewing's treatise on magnetic hysteresis. In chapter ii. of this paper Duhem treats of a system in which the hardness undergoes only secular changes defined in a former paper of the series. If this be denoted by x, one of the two variables, changes depending on x will be very small. The system will behave approximately as a system with only one normal variable ; systems of this kind have been discussed in the fifth paper of the series (chap. i.). In this principle consists the method of approximation explained in the present paper. If A, X, express the external

conditions corresponding to the variables a, x, then a "natural state" is defined by reducing to zero two functions—

$$f_a(a, x, T, A, X) = 0$$

$$f_x(a, x, T, A, X) = 0$$

The equations obtained by using instead of the variable x a certain constant value C, from which x differs but little as above explained, namely—

$$G_a(a, T, X, A, C) = 0,$$

and— $$x = E(a, T, X, A, C),$$

define a "fictive natural state."

It is shown that any cycle of variations in the external conditions causes the system to undergo permanent changes of the x and a components, which may be calculated approximately by means of two supposed "fictive" systems, in one of which a and in the other x is unaffected by hysteresis. S. H. B.

83. *Relationships between Thermodynamic Fundamental Functions.* **J. E. Trevor.** (Journ. Phys. Chem. 4. pp. 570–584, Oct., 1900.)—The fundamental functions are the same as those discussed by Trevor in his former papers [Abstracts Nos. 71 and 635 (1900)], namely, E, F, G, H, which themselves depend on the four usual variables, p, v, θ, η, in the form following :—

E (the energy) satisfies the equation—

$$dE = -pdv + \theta d\eta,$$

F (the free energy) $= E + \theta\eta$,
G (the heat function) $= E + pv$,
H (the entropy function) $= E + pv - \theta\eta$.

The author now considers the two known relations :—

$$\left.\begin{aligned} \frac{d}{dp}\frac{(H_2 - H_1)_{p\theta}}{p} &= -\frac{W_{12}}{p^2} \\ \frac{d}{d\theta}\frac{(H_2 - H_1)_{p\theta}}{\theta} &= -\frac{Q_{12}}{\theta^2} \end{aligned}\right\} \quad (1)$$

in which p and θ denote the equilibrium values of the pressure and thermodynamic temperature, W_{12} and Q_{12} the work and heat respectively absorbed by the system in passing from state 1 to state 2. The subscripts p, θ indicate that the change is effected with p and θ constant, the mass remaining unchanged during the operation.

The object of the present paper is to find other relations of the form (1). To effect this object each of the fundamental functions, E, F, G, H, has to be expressed in terms of each of the others. As an example of the results the author obtains—

$$-v^2 \frac{d}{dv}\frac{(E_2 - E_1)_v}{v} = (G_2 - G_1)v,$$

where the subscript v indicates that v is to be constant during the change from state 1 to state 2.

Then follows a discussion of individual phases. The integration of

$dE = -pdv + \theta d\eta$ gives $E = -pv + \theta\eta + \Sigma\mu m$, the summation including all the masses of the n independent variables composing a phase. The type of the resulting equations is—

$$G = -v^2 \frac{d}{dv}\frac{E}{v}$$

$$F = -\eta^2 \frac{d}{d\eta}\frac{E}{\eta}$$

$$c = -\Sigma m^2 \frac{d}{dm}\frac{E}{m} - (n-1)E$$

S. H. B.

REFERENCES.

84. *Low Temperatures.* **B. Dessau.** (Phys. Zeitschr. 2. pp. 20–22, Oct. 13; 37–44, Oct. 20; and 60–62, Oct. 27, 1900.)—The author gives a summary of recent work in connection with low temperatures. He deals with the methods of producing them; with the influence of extreme cold upon the physical and chemical properties of bodies; Behn, Trowbridge, and Tilden's work on specific heats; methods of measuring low temperatures; resistance, thermoelectric force, and dielectric capacity at low temperatures; and the solubility of bodies in condensed gases. E. E. F.

85. *Kinetic Theory of Gases.* **S. H. Burbury.** (Ann. d. Physik, 3: 2. pp. 355–365, Oct., 1900.)—The author deals with two objections raised by G. Zemplén against his fundamental principles of the kinetic theory of gases [see Abstract No. 1817 (1900).] He acknowledges that these principles require further explanation. E. E. F.

86. *Convection Currents in a Liquid Layer.* **H. Bénard.** (Journ. de Physique, 9. pp. 513-524, Oct., 1900.)—Paper similar to that referred to in Abstract No. 1815 (1900). A. D.

87. *Boiling-points of Mixtures of Chloral and Water.* **J. C. Christensen.** (Journ. Phys. Chem. 4. pp. 585–597, Oct., 1900.)—A long series of measurements of the boiling-points of mixtures of chloral and water is given, together with curves plotted therefrom. T. H. P.

SOUND.

88. *Mechanical Effect of Sound-Waves.* **B. Davis.** (Amer. Journ. Sci. 10. pp. 231–236, Sept., 1900.)—If a small cylinder, which is closed at one end, is placed in a stationary sound-wave, it will not only arrange itself perpendicularly to the motion of the wave, but will actually move across the wave in a direction perpendicular to the stream-lines. The closed end of the cylinder is driven towards the wall of the pipe containing the stationary sound-wave. The author produces a continuous rotation of a kind of anemometer wheel in which the cups are replaced by gelatine capsules with flat bottoms, the whole being mounted on a needle-point by means of a glass pivot. The rate of revolution at any point of the organ-pipe is nearly proportional to the velocity of the vibrating air particles at that point. According to Bernouilli, a gas in motion is virtually less dense than a gas at rest. The air in each capsule cylinder is at rest, while that on the outside of it is in motion. The kinetic energy evolved is due to the difference of density on the two sides of the closed end of the cylinder. E. E. F.

89. *Longitudinal Vibrations of Rods.* **G. Jäger.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 81-91, Jan.–March, 1900.)—The lowest longitudinal vibration of a rod free at both ends is an octave higher than the lowest longitudinal vibration of the same rod when one end is absolutely fixed. Such a "fixed" end may be obtained by pressing the rod firmly against a block of lead, or, better, by pressing it into a conical depression in the block. A comparatively small block suffices to obtain the fundamental note and a variety of overtones. Thus for a rod 1 m. long and 6 mm. thick a cylindrical lead weight of 3 cm. radius and 1 cm. thickness suffices. If a table is substituted for the lead block a yet lower note is obtained, due to the vibration of the rod as a whole in the direction of its length. The full number of tones of a rod fixed at both ends may be produced by providing both ends with lead blocks. The notes yielded are very pure. The ease of production is not impaired by shortening the rods. The shortening may be carried so far as to surpass the limit of hearing. With rods less than 4 cm. in length pitches of 50,000 may be attained, or more if real rods are used, which have a high elasticity.
E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

90. *Electron Theory.* **W. McF. Orr.** (Phil. Mag. 50. pp. 269–278, Sept., 1900.)—Various points in the theory of electrons as developed by Larmor are criticised. The illustration of the origin of statical mechanical attraction is considered inadequate, inasmuch as it does not show any machinery by which the mobility of the electrons is provided. Some analysis, slightly modified from that of Larmor's, is given showing the conditions of equilibrium of an element of ether. The whole paper is the outcome of a discussion with Larmor, whose rejoinder to this paper is appended. G. E. A.

91. *Dust Figures for Electrostatic Fields.* **D. Robertson.** (Elect. Rev. 47. pp. 370–372, Sept. 7, 1900.)—A wooden frame is held by a clip stand, and in this frame a plate of glass rests loosely. Pressing against the under side of the glass plate, electrodes of tin-foil of any desired shape and size are used. The electrodes are connected by bare wires to the terminals of an electrical machine. The machine is worked to give the electrostatic field, and at the same time the plate is sprinkled with dust and the holder of the clip stand tapped. When the best effect is obtained the tapping should be stopped, and then the bare leads of the machine short-circuited by a wire held ready for the purpose. For the dust, that obtained from mahogany by a tenon saw is suitable. E. H. B.

DISCHARGE AND OSCILLATIONS.

92. *Unipolar Discharge.* **J. Stark.** (Phys. Zeitschr. 2. pp. 17–18, Oct. 13, 1900.)—When the charge of a body is increased beyond a certain point, a disruptive discharge takes place through the surrounding medium. On raising the temperature of the body to incandescence, the discharge potential is lowered, and the lowering is greater for negative than for positive charges. Hence at a certain difference of potential, either positive or negative, a negative charge alone will be discharged. This is the unipolar discharge produced by heating, and the author offers the following explanation for it. At the surface of the glowing body, positive and negative ions are liberated, partly owing to the high temperature, and partly owing to the ultra-violet light radiated from the body. Under the force exerted by the charged body, these ions are driven into the gas, and produce or increase the conductivity of the latter. If the body is negatively charged the negative ions will be sent out with the greater force, and since their speed is greater in every case than the speed of the positive ions, they will produce a greater amount of gaseous ionisation than the positive ions would in a similar case. That ionisation, and not mere field strength, is the determining factor is shown by the fact that if a carbon filament charged to — 100 volts is confronted with an electrode at — 5,000 volts, no charge passes, since the negative ions cannot leave the glowing filament. But a discharge passes at once on earthing the electrode. E. E. F.

93. *Effect of Heat on a Vacuum Discharge.* **J. Stark.** (Ann. d. Physik, 3. 2. pp. 221–242, Oct., 1900.)—As regards change of potential gradient with current strength, the dark spaces are equal among each other, and so are the bright spaces. In the former it increases with the current, in the latter it decreases. Under the influence of heat, the luminous layers show a decrease of potential gradient and an increase of current intensity. The changes described occur first slowly with increasing temperature, then rapidly, and then again slowly. The dark spaces show an opposite behaviour. At a red heat the bright layers become dark and acquire the properties of the latter. E. E. F.

94. *Helical Discharge.* **M. Toepler.** (Phys. Zeitschr. 1. pp. 497–498, Aug. 11, 1900.)—The author describes the conditions under which Ruhmer's helical discharge [see Abstract No. 2204 (1900)] is observed in detail. In the open air the discharge resembles the positive brush with helical stalk described by the author some time ago. In a vacuum the phenomenon is not observed with a continuous current, but only after the discharge has been made disruptive by inserting one or two spark-gaps. The irregular luminous lines shown with feeble currents coalesce into a single band when the current-strength is increased, and the band runs in a helical path along the wall of the tube. As the current-strength increases still further the band detaches itself from the wall of the tube, its pitch becomes higher and eventually it contracts into a nearly straight band joining the two electrodes. Like the helical brush discharge in the open air, the band is carmine red at the anode, and blue along the rest of its length. Pitch and direction of winding often change abruptly and without assignable cause. Sometimes it suffices to trace a screw line with the hand in the opposite sense, to reverse the screw. The helical band turns about its axis, as observed by Ruhmer, apparently descending from the anode to the kathode. The velocity of rotation is much affected by electrostatic influences. E. E. F.

95. *Thermal Extinction of Electric Glow.* **J. Stark.** (Ann. d. Physik, 3. 2. pp. 243–246, Oct., 1900.)—If the influence of heat upon the electric glow in a gas is to be determined it is not advisable to heat the whole tube, as in that case the conditions of discharge are totally changed. The author therefore employs a looped carbon filament, with its plane normal to the axis of the tube, carefully insulated, and rendered incandescent by an independent current. To avoid justifying Lehmann's supposition that the dark space observed round the glowing body is a dark kathode space due to an independent discharge, the author works with a high-potential continuous current rather than an induction coil. All the results point to the theory that a simple increase of temperature stops the luminosity of a gas under an electric discharge. Hittorf's idea that this is due to a stoppage of the phosphorescence is hardly tenable in view of the dark spaces observed at ordinary temperatures. The probable explanation is that the increase of temperature brings about an increase in the conductivity, and a consequent reduction of the potential gradient. This is corroborated by the fact known for some time, that in a stratified discharge, the dark portions are the portions of minimum potential gradient. E. E. F.

96. *Sensibility of Spectroscopy.* **F. Emich.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 411–414, May, 1900.)—By employing Geissler tubes containing hydrogen and a mixture of oxygen and hydrogen at very low pressures, the author has found that masses of hydrogen as small as 7×10^{-14} milligrammes may still be recognised by the red spectral line. J. B. H.

97. *Ionisation by Ultra-Violet Light.* **P. Lenard.** (Ann. d. Physik, 3. 2. pp. 298–319, Oct., 1900.)—The author measures the velocity of ions produced by ultra-violet light by forcing a current of air through two flat nets in succession. The nets are made of linen threads rendered conducting by means of soap solution. The space between them is illuminated by ultra-violet light, taking care, however, that the limit of the illuminated space is 1 cm. away from the first net, which is positively charged. The second net is put to earth. When the blast is working without the rays there is no loss of charge, but when the rays are turned on, with or without the blast, there is a loss of charge due to the ionisation of the air. As the blast increases in strength the negative ions which seek to approach the positively charged screen are blown back, and when the velocity of the air is 1·3 m. per second there is no more loss. That, therefore, is the velocity of the negative ions. With the e.m.f. used this gives 3·13 cm. per second for a potential gradient of 1 volt per centimetre. The corresponding value for the positive ions is 0·0015 cm. per second. The author obtains for s, the sum of the radii of the molecule and positive electron, the value 56×10^{-6} mm., or about 70 times the diameter of a molecule. This means that the positive electron consists of a large number of atoms, even if it only carries one elementary charge, e.

E. E. F.

98. *Electric Conduction in Gases.* **J. Stark.** (Phys. Zeitschr. 2. pp. 4–6, Oct. 6, 1900.)—Local differences in the intensity of the positive and negative current produce rarefactions and concentrations of the electric ions. In regions of concentration there is a maximum in the steepness of the potential gradient, and in regions of rarefaction there is a minimum. The accumulation of ions also produces local force charges, which modify the electric field due to the electrodes. At the minima of the potential gradient the external e.m.f. must work against the local forces, but this work is recovered in the maxima. The former state corresponds to that of an accumulator which is being charged by a current, the latter to an accumulator which discharges itself and is traversed at the same time by an external current in the same direction. Hence the kinetic energy appearing in any given portion of the gas cannot be taken as a measure of the resistance in that portion. The quantity of heat developed in the bright strata is greater than that developed in the dark strata. This is now no longer in contradiction with the fact that the resistance of the bright strata is less than that of the dark strata. E. E. F.

99. *Electrical Conductivity in Gases traversed by Kathode Rays.* **J. C. McLennan.** (Roy. Soc., Proc. 66. pp. 375–378, July 9, 1900; and Roy. Soc., Phil. Trans. 195. pp. 49–77, Nov. 3, 1900.)—The object of the experiments described was to investigate the nature of the conductivity produced in different gases when kathode rays of definite strength pass through them. The tube used for the production of kathode rays was similar to that devised by Lenard. The following are the results deduced from the experiments: (1) The conductivity impressed upon a gas by kathode rays is similar to that produced by Röntgen and uranium rays, and can be fully explained on the hypothesis that positive and negative ions are produced by the radiation throughout the volume of the gas traversed. (2) When kathode rays are allowed to fall upon insulated metallic conductors surrounded by air at atmospheric pressure: (*a*) such conductors, if initially uncharged, gain a small limiting negative charge; (*b*) positive charges are completely dissipated; (*c*) negative charges drop to a small limiting value; (*d*) the loss of

charge is due to the action of the ionised air surrounding the conductor, and the value of the limiting negative charge is determined by the extent of the conduction in this air. (3) The ionisation produced in a gas by rays coming from the aluminium window in a Lenard discharge tube is due to kathode rays and not to Röntgen rays. (4) Lenard's results obtained by fluorscopic methods on the absorption of kathode rays are confirmed by a study of the ionisation these rays produce in gases. (5) When kathode rays of a given strength are passed through a gas, the number of ions produced in 1 c.c. depends only upon the density of the gas, and is independent of its chemical composition. (6) It is inferred that with rays of constant intensity the ionisation in any particular gas varies directly with the pressure. This was not verified directly by experiment on account of the great absorption of the rays by gases at ordinary pressures ; but the absorption has been shown by Lenard to vary directly as the pressure and the ionisation is proportional to the absorption. (7) The relative ionisations produced by kathode rays of constant intensity in air, oxygen, nitrogen, carbon dioxide, hydrogen, and nitrous oxide, at the same pressure, are expressed by the numbers which represent their densities. (8) With kathode rays, just as with Röntgen rays, the number of ions produced in a gas bears a definite ratio to the amount of the radiant energy absorbed. J. J. S.

100. *Explanation of the Dark Kathode Space.* **W. Kaufmann.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 137–141, 1900.)—Hertz and Goldstein have shown that the so-called "negative glowlight" (Goldstein's third kathode-layer) is closely connected with the diffusion of the kathode rays produced by gases. An attempt is here made to base an explanation of the negative glowlight and the dark kathode space upon the fact that kathode rays dissociate the gas through which they pass, and render it conducting. Inasmuch as this conductivity disappears rapidly after the discharge ceases, it must be assumed that the ions into which the gas molecules split combine again of themselves. It is further assumed that the rapidity of this combination follows the chemical law of mass-action, *i.e.*, that the number of ions combining per second per cubic centimeter is $R = \alpha n_1 n_2$, where n_1 is the concentration of the positive ions, n_2 of the negative ions, and α is a constant. The validity of this law for conducting gases has been demonstrated by Rutherford (Phil. Mag. (5) 44. p. 422, 1897) and McClelland (*ib.* 45. p. 29 1898). The explanation advanced is that the negative glowlight arises through the impact of ions during their combination (whilst the ions, before coming to rest, still execute oscillations about their position of rest). A theory based on these assumptions is sketched, and its results appear to be in accordance with observed phenomena. D. E. J

101. *The Dark Kathode Space.* **E. Goldstein.** (Deutsch. Phys. Gesell Verh. 2. 11. pp. 142–144, 1900.)—In spite of Kaufmann's suggested explana tion [see preceding Abstract] the author adheres to the views which he ha previously expressed [Abstract No. 456 (1899)] as to the meaning of the dar kathode space. The glowlight (so-called third layer) consists of rectilinea rays. These do not spring from the kathode itself, but from the ordinar kathode rays (K_2-rays)—from all parts of these rays and in all direction At first sight the existence of the "dark kathode space" seems to tell agains this view. For as the K_2-rays also pass through the (apparently) dark kathod space, one would expect the glowlight to appear in it.

It is known, however, that a kathode exerts a repulsion (deflexion) upo

all magnetically deformable rays, and the rays which constitute the glowlight ("glow-rays") are such. Now suppose, to begin with, that glow-rays actually proceeded from all points of the K_2-rays, including those lying nearest to the kathode. These would be repelled for a given distance from the kathode, until the repulsion for such rays became ineffective. We should thus have formed around the kathode a space free from glow-rays—the so-called dark kathode space. The author considers that this view explains most of the phenomena known in connection with the dark space. It explains how its form varies with the form of the kathode: one has only to assume that each kathode element exerts a repulsion in the direction in which it radiates. Further applications of the principle explain the extension of the dark space when the pressure diminishes; also its restriction by placing another kathode opposite, or by the action of a magnet. D. E. J.

102. *Dimensions of the Dark Kathode Space in Different Gases.* **H. Ebert.** (Deutsch. Phys. Gesell., Verh. 2. 9. pp. 99–106, 1900.)—In a previous investigation [Abstract No. 1897 (1899)] the author has shown that the thickness of this dark space adjoining the luminous kathode-layer (Hittorf's dark kathode space or the second Goldstein kathode-layer) can be expressed by the relation $d \cdot p^m = d_0$, where p is the pressure, and m (< 1) and d_0 are constants which are characteristic for the given gas and the conditions of the discharge. He is now engaged in investigating monatomic gases, and meanwhile reports further on diatomic gases as follows:—(1) So long as the pressure is comparatively high and the kathode is not wholly covered with glowlight, the exponent m is large. It can even attain to unity: the thickness of the dark space is then inversely proportional to the pressure. (2) As soon as the electrode-plate is covered with the glowlight, d increases more slowly with increasing p (*i.e.*, m becomes smaller). For the same plate (aluminium, 1 cm. radius and 0·51 mm. thick) the following mean values of m were obtained:—H_2, 0·55; CO, 0·60; N_2, 0·57; CO_2, 0·52; air, 0·49; O_2, 0·46. It is noticeable that they group themselves about the number $\frac{1}{2}$; if they had exactly this value, the law of increase would be given by the relation—

$$d_1 : d_2 = \sqrt{p_2} : \sqrt{p_1}.$$

The values of the other constant d_0 (the thickness when $p = 1$ mm.) show more considerable differences. Thus for the above plate the values were:—H_2, 2·91; Co, 2·49; N_2, 2·21; Co_2, 2·08; air, 1·97; O_2, 1·80. The gases are here arranged according to the thickness of the dark space. The mixture air stands between its constituents N_2 and O_2; CO_2, which is shown by the spectroscope to decompose into CO and O, stands between these gases. (3) As the pressure gradually diminishes, when the dark space has attained a certain thickness Δ, m suddenly attains a larger value. The values of Δ corresponding to this sudden change lie between 2 and 2·2, and the corresponding pressures are as follows:—H_2, 2·0; CO, 1·3; N_2, 1·0; CO_2, 1·1; air, 0·9; O_2, 0·7. The pressure of the mixture air is $(\frac{4}{5} \times 1{\cdot}0) + (\frac{1}{5} \times 0{\cdot}7) = 0{\cdot}9$. (4) At still lower pressures the relation $d \cdot p^m = d_0$ again holds good, the values of m varying from 0·97 (H_2) to 0·78 (O_2). The paper concludes with a theoretical discussion as to the physical significance of m and d_0. D. E. J.

103. *Photo-Electric Rays.* **E. Merritt** and **O. M. Stewart.** (Phys. Rev. 11. pp. 230–250, Oct., 1900.)—The authors trace the connection between kathode rays and the particles discharged from negatively charged bodies under the influence of ultra-violet light. For simplicity the authors call the

streams of particles discharged through the influence of ultra-violet light "photo-electric rays," and they then proceed to show that they are of essentially the same nature as kathode rays. This is the conclusion already arrived at by J. J. Thomson, who has even determined the ratio l/m for these rays, and found it to lie between $5{\cdot}8 \times 10^6$ and $8{\cdot}5 \times 10^6$. The authors employed an arc lamp in place of a spark-gap as a source of ultra-violet light, and their vacuum tubes were essentially the same as Lenard's, with a slanting side-tube to direct the ultra-violet rays on to the kathode. Their magnetic-deflection experiments led them to the conclusion that two kinds of particles are concerned in the photo-electric discharge: (1) The small rapidly moving corpuscles of the photo-electric rays, forming a fairly compact stream normal to the kathode; (2) the relatively heavy and slowly moving negative ions, which form a stream having the same general direction as the photo-electric rays, but much more diffuse and not appreciably affected by a magnetic field. E. E. F.

104. *Effect of Electrical Stimulus on Inorganic and Living Substances.* **J. C. Bose.** (Electrician, 45. pp. 774–777, Sept. 14; 864–865, Sept. 28; and 897–901, Oct. 5, 1900. Paper read before the British Association.)—The effects of electric radiation upon certain substances show that the changes produced, as in the coherer, are of the nature of a molecular strain. The strain may be purely elastic, or may lead to a molecular rearrangement, such as produces the change of allotropic form in phosphorus. A very perfect instance of molecular elasticity is presented by lead bromide. A coherer containing that substance shows galvanometer deflections varying with the intensity of the radiation and even with every flicker in the exciter. Absence of response or "fatigue" is due to the overstrained condition of the substance. Fe_3O_4, owing to its chemical stability, offers a good case of rapid recovery. The author reproduces a curve showing the effect of an instantaneous flash of electric radiation upon a coherer containing Fe_3O_4, and also a curve showing the response of a muscle to electrical stimulus. The aspect of the two curves is very similar. The muscular curve shows several waves of elastic after-vibration, such as is known to take place in the case of the retina. This after-vibration is also noticed in the case of certain sensitive inorganic substances. The various effects produced on muscles under intermittent stimulation are absolutely identical with those of the inorganic substance Fe_3O_4.

Further parallelisms may be shown to exist between living and dead matter in the influence of temperature in increasing the sensitiveness and facilitating the recovery of a coherer and a muscle respectively, the similar effects of fatigue in the two cases, and the effect of adding small proportions of a foreign substance or "poison." The curves representing these different effects are very similar in the two cases. The author finally proceeds to bridge the gap between purely physical and physiological processes by tracing the development of memory, the most distinctive attribute of the living organism, from the phenomenon of "recurring after-effect." The latter is a physiological phenomenon of the retina which has its counterpart in the oscillations of conductivity presented by a coherer containing magnetic oxide of iron after it has been exposed to radiation. The latter even shows a "tetanic effect," consisting of short and rapid oscillations about the maximum conductivity. E. E. F.

105. *Reflection and Transmission by Condensers of Electric Waves along Wires.* **E. H. Barton** and **L. Lownds.** (Phil. Mag. 50. pp. 357–392, Oct., 1900.

Paper read before the Physical Society of London.)—If an electric current travels along a wire and a condenser be interposed the wave is partly reflected and partly transmitted, and with difference of phase in either case. The mathematical theory of the reflected and transmitted waves is given by O. Heaviside, whose work in the main the present writers follow. The existence of the reflexion was proved experimentally by Geitler (Wied. Ann. 49. pp. 184–195, 1893.)

The writers arranged an apparatus for observing the reflected wave trains. It is shown in the following diagram :—

Here A is the battery, B and C are the primary and secondary coils, G the spark-gap. The line is represented by SEDTT'E'S', and consists of two parallel copper wires. EE' is the electrometer which has a single plane needle initially unchanged, and suspended by a fine quartz fibre between two discs attached to the line at E and E'. It is shown that the reflexion of waves at the electrometer, regarded as itself a condenser, is negligible. TT' is the terminal bridge which absorbs the waves on arrival at the end of the line. DD' is one of the condensers used to reflect the waves. In the experiments these condensers were placed at different parts of the line. For instance, in observing the transmitted system they are inserted at FF'. The waves generated by the primary oscillator undergo rapid damping, so that the tail, after ten or twelve waves, is almost negligible.

The theory is then given on the hypothesis that the circuit is what Heaviside terms a distortionless circuit. The actual experiments are then described and the results compared with theory. The writers acknowledge their obligation to Heaviside, both in respect of the general theory and for special help in the present paper. S. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

106. *Static Charges in Magnetic Fields.* **V. Crémieu.** (Comptes Rendus, 131. pp. 578–581, Oct. 8, 1900.)—Lippmann applied the principle of the conservation of energy to the experiments of Rowland upon electric convection, and showed that, according to his view, changes of magnetic induction ought to produce movements of electrified bodies in the magnetic field. The movement should be proportional to $\mu \frac{dH}{dt}$, where μ is the charge on the suspended body, and $\frac{dH}{dt}$ the rate of change of magnetic induction. The direction of the movement should be the same as that of a current induced in a wire situated along the trajectory of the moving body, under the same magnetic influences. Lodge published (Phil. Mag., p. 469, 1889) an account of experimental work which left the proof of the movements uncertain. Crémieu now describes researches made with a pivoted aluminium disc, separated into two parts by mica, and free to turn in its own plane in a magnetic field. This apparatus should have produced a movement of a spot of light of about

120 mm., as calculated from the dimensions of the parts and the values o $\mu \frac{dH}{dt}$. But no movement whatever was observed. The author conclude that there is no displacement of a charged body due to magnetic influence in such a direction. R. A

107. *Motion of Electrolytes in a Magnetic Field.* **O. Urbasch.** (Zeitschr Elektrochem. 7. pp. 114–117, Sept. 6, 1900.)—Two different electrolytes ar poured into a flat dish, one above the other, say concentrated and dilut sulphuric acid, or concentrated $CuCl_2$ and HCl, and the dish is brought int a strong magnetic field whose lines of force diverge from a point, the poin being a narrow pole-piece placed opposite a broad one. Under thes circumstances the liquid in the dish rotates. The rotation may be place in evidence by strewing the surface of the liquid with lycopodium powde On reversing the magnetic field, the direction of rotation is also reverse The rotation continues as long as the two liquids have a separating surface The direction of rotation depends also upon the electrolytes employed. dilute HCl over $CuCl_2$ is replaced by concentrated HCl, the direction o rotation is reversed, and at certain ionic concentrations no rotation at a takes place. The explanation is based upon the wandering of the ion across the dividing surface, near which a magnetic circular field is generate by the surplus energy of the faster ions. This circular field, acted upon b the divergent field, produces the rotation observed. Rotation also take place when a metallic plate, covered on one side with paraffin, is brought int a solvent. In the case of zinc immersed in $CuSO_4$ the circumferentia velocity may attain 5 to 10 cm. per second. E. E. F

108. *Change of Resistance in Iron by Magnetisation.* **A. Gray** and **T Taylor Jones.** (Roy. Soc., Proc. 67. pp. 208–215, Oct. 31, 1900.)—Th difference of the fractional increments of resistance of two coils of iron wir placed in the same magnetic field so as to have the wire of one of the coi magnetised longitudinally and of the other transversely, is here determine as a function of the strength of field and also of the intensity of magnetis tion. Owing to the very large demagnetising factor for a wire magnetise transversely the intensity of magnetisation in its case is very small.

The fields were produced by means of a solenoid 1 metre long, furnishe with a double cylindrical core through which a flow of water could be mai tained to secure a constant temperature. The two iron wire resistances we wound non-inductively, the one longitudinally, the other transversely, on rod of wood 60 cm. long, which was placed centrally in the axis of the soleno during the resistance experiments. A Wheatstone's bridge arrangement w used to compare the resistances.

To determine the intensity of magnetisation of the longitudinally ma netised wire as a function of the field, a number of pieces of the same wire we placed side by side in a glass tube on which a small ballistic coil was woun The tube was placed in the solenoid, and a B-H curve determined ballis cally by reversals of the current in the solenoid.

The increase of resistance of the coil magnetised longitudinally is alwa the greater. If P and Q are the resistances of the two coils, then

$$\Delta\phi \equiv \frac{\Delta P}{P} - \frac{\Delta Q}{Q}$$

is measured as a function of H. The curves representing $\Delta\phi$ as a function B^4 and I^4 are approximately straight lines. J. B.

109. *Measurement of Galvanometer Resistance.* **W. S. Day.** (Phys. Rev. 1. pp. 251–254, Oct., 1900.)—The method proposed is to vary the potential ifference on the terminals of the galvanometer and measure the additional esistance required to be inserted to maintain the deflection constant. The otential difference is obtained on a bridge wire through which a steady urrent is maintained. If three readings be taken embracing resistances of ne bridge wire proportional to 1, 2, and 3, the galvanometer resistance is $a - b$, where a and b are the resistances inserted to maintain the deflection onstant in the two latter cases. If the bridge wire resistance is negligible ompared with that of the galvanometer, two readings are sufficient, and if hese embrace resistances proportional to l and $l + m$, $g = \frac{l}{m} a$. G. H. B.

110. *Measurement of High Resistance.* **O. N. Rood.** (Amer. Journ. Sci. 0. pp. 285–294, Oct., 1900.)—In the method adopted for measuring high esistances the electricity is allowed to slowly accumulate till it reaches a ertain potential. The apparatus employed was a modification of a single af electroscope which served as an electrometer. A brass rod was supported n a bar of ebonite which was placed on two rods of the same substance astened on a base of ebonite. The rods and the bar were painted with melted esin. The rod carried an aluminium leaf, bluntly pointed below and attached bove by a gold-leaf hinge. Opposite to the lower part of the aluminium leaf t a short distance was fixed a plate of sheet brass faced with platinum-foil; his received the charge from the aluminium leaf when its potential was ufficiently raised. The distance of the plate from the leaf could be varied by micrometer screw.

A sealed glass tube 130 cm. in length was made to establish connection etween a Leyden jar charged to a potential of 12,000 volts and the electro- neter. In this case the electricity advanced slowly over the entire length of he tube, the electrometer not being at all effected for some time. In about ive minutes it gave regular strokes; the tube had assumed the stationary ondition, and had nearly the same potential over its whole length except ear the electrometer, where for 3 or 4 cm. it was lower. For half an heur was allowed to deliver charges to the electrometer with much regularity, he rate being observed with a stop-watch.

After the construction of a set of units of high resistance, the resistance of tube of soft German glass 27 cm. in length, which had been for some days n a box dried with sulphuric acid, was measured. This was found to be 50,000 megohms. Under the influence of the current at 110–112 volts it ncreased to 380,000 megohms, the hygrometer indicating 43 per cent. of noisture. On a later day, when the hygrometer indicated 53 per cent., the esistance of the tube had fallen to 180,000 megohms.

The results of experiments on silk, paraffin paper, mica, jade, guttapercha, lack sealing-wax, ebonite, amber, and resin are also given. In the case of bonite in dry weather inductive effects occurred, and if the ebonite con- ducted at all in the regular way, such conduction was masked by the inductive ffects. J. J. S.

111. *Electrical Properties of Glass.* Part. II. **A. Gray** and **J. J. Dobbie.** Roy. Soc., Proc. 67. pp. 197–207, Oct. 31, 1900.)—An account is given of the continuation of experiments formerly described [see Abstract No. 808 (1898)] n the electrical qualities of specimens of glass of which the chemical com- position was determined by analysis. In this paper the results of further

experiments on eight different kinds of glass are given in a table which contains the percentage composition of the specimens and their specific resistance and specific inductive capacity at different temperatures. It appears that potash glasses have very much higher resistances than soda glasses. In one case the substitution of soda for potash in the composition of the glass was found to diminish the resistance of the glass to $\frac{1}{1300}$ of its former amount. It was found that the effect of annealing glass is very greatly to increase its specific resistance. In the case of lead-soda glass the specific resistance was raised to three times its former value. Annealed glass is therefore a much better insulator than unannealed glass. J. J. S.

112. *Stability of Temperature in an Electric Conductor.* **H. E. Wimperis.** (Electrician, 45. pp. 929–930, Oct. 12, 1900.)—As the electrical resistance of most metals increases with the temperature according to a nearly linear law, the author thought that there might occur cases of possible instability of temperature when the conductor carried a constant current. In the case of a wire of some conducting metal carrying a constant current, let the temperature of some small portion be raised (by a flame, for instance), the resistance of this portion is increased, and therefore the heat generated at this portion by the current will be greater, and the temperature will tend to rise still further. There are two phenomena that tend to oppose this rise of temperature; they are increased radiation and the fact that heat is conducted away from this portion through the wire itself. The latter result can be made very small by suitably designing the wire. Whether or no the temperature of the small treated portion will rise or fall on removing the flame will depend on which is greater, the increase of heat owing to the increase in resistance or the decrease of heat due to increased radiation. If two curves are plotted, the abscissæ being temperatures and the ordinates heat gained or lost per second at those respective temperatures, the first curve being heat gained due to the current and the second heat lost due to radiation, where the curves cut one another will obviously be the equilibrium point of temperature. If the slope of the radiation curve is greater than that of the current curve at the point where they cut one another, the temperature will be stable; if the reverse, it will be unstable. Finally, it is found that instability is impossible with any metal known, since the law connecting the resistance of a metal and temperature is nearly linear and the radiation curve is convex to the axis of temperature. E. C. R.

113. *Neutral Point of Thermo-couples.* **A. Abt.** (Ann. d. Physik, 3. 2. pp. 320–327, Oct., 1900.)—The author describes a simple method of determining the neutral point in thermocouples, which is specially suited to demonstration purposes. It is based upon the equation—

$$E = (t_1 - t_2)[a + b(t_1 + t_2)]$$

The temperatures of the junctions are changed until the current disappears. When that occurs, the neutral point is the arithmetical mean of the temperatures t_1 and t_2 of the junctions respectively. The arrangement as described consists of two wooden frames with openings closed by plates of asbestos, one on each face of the frame. Holes are bored in the plate, and thick steel rods are inserted through the holes. One end of each rod contains receptacles for the bulb of a thermometer and one for junction of the thermocouple, while the other is heated by a Bunsen flame. Images of the thermometers and of the galvanometer scale are thrown upon a screen, and the heating is carried

n until the current disappears, or until it reaches a maximum, while one unction is kept at the temperature of the room. The neutral point is 117° in brass-lead couple, 276·8° in an iron-silver couple, and 232° in an iron-zinc couple. E. E. F.

114. *Thermo-magnetic Phenomena.* **G. Moreau.** (Journ. de Physique, 9. pp. 497–506, Sept., 1900.)—The author interprets the thermo-magnetic effect of Nernst by regarding it as a Hall effect of the electromotive forces that Kelvin introduced into his theory of thermoelectric currents. The behaviour of nickel appears to be anomalous. If it is supposed that, in the case of nickel, Thomson's coefficient, σ (the specific heat of electricity), does not equal the e.m.f. of true contact, it may perhaps be stated in general that the thermo-magnetic effect is a Hall effect of the true contact electromotive force of Thomson. [See Abstracts Nos. 860 and 1454 (1900)]. J. J. S.

115. *Thermoelectricity of Electrolytes.* **A. H. Bucherer.** (Ann. d. Physik, 2. pp. 204–209, Oct., 1900.)—Starting from van't Hoff's osmotic pressure formula,

$$V dP = v d\phi,$$

the author arrives at the equation

$$E = \frac{4{\cdot}35 \times 10^{-5}}{\gamma} \int_{T_1}^{T_2} (2N - 1)\, R dT,$$

where γ is the number of valencies with which the metallic element of the electrolyte is bound to the non-metallic element. The same equation has been derived by Duane from Nernst's theory. E. E. F.

116. *Electric Effect of Light upon Green Leaves.* **A. D. Waller.** (Roy Soc., Proc. 67. pp. 129–137, Oct. 26, 1900.)—Under certain favourable conditions, which are not as yet completely determined, green leaves show a true electrical response to light, consisting in the establishment of a potential difference between the illuminated and the non-illuminated half of a leaf which may amount to 0·02 volt. This effect shows a remarkable similarity with the effect of electric excitation upon nerve and muscle. In the human nerve substance, electric excitation causes a current from the resting to the active tissue, followed after a few seconds by a smaller current in the opposite direction. In iris leaves, the current flows from the illuminated to the shaded half of the leaf during illumination, and in the opposite direction for about five minutes after the illumination has ceased. The response takes about four seconds to set in, and it is only the young and growing leaves that show any response. When the stimulus is repeated, a certain amount of fatigue is shown, as in all organic structures and even in some inorganic substances. But no fatigue is shown when the leaf is given an hour to recover between each stimulus. The tobacco plant acts like iris, but in tropæolum and other plants the currents are in the opposite direction. That chlorophyll is essential to this photo-electric reaction is shown by the fact that the petals of flowers do not show it. E. E. F.

117. *Determination of Frequency.* **A. Samojloff.** (Ann. d. Physik, 3. 2. pp. 353–354, Oct., 1900.)—The author describes a very simple method of determining the frequency of an alternating electric light current. In the course of some physiological experiments on the intermittent excitation of the

retina, made with a disc consisting of black and white sectors, he noticed that on illuminating it by a glow-lamp the disc appeared to stand still when revolving at a certain rate. That rate was the rate at which the alternations of black and white at any given point of the disc were synchronous with the alternations of the luminosity. The periodical partial extinctions of the filament, though imperceptible to the eye, were evidently sufficient to make the intermediate grades between a maximum or minimum of whiteness disappear, and thus to produce the appearance of a disc at rest. Hence it is only necessary to place a revolving disc near the lamp and to alter its speed until it appears to stand still. The number of white sectors, multiplied by the revolutions per second, gives the number of reversals per second of the current. The frequency of a Wehnelt interrupter may be similarly determined by mounting it in parallel with an arc lamp and treating the latter as an alternate-current lamp. This may be done in daylight. E. E. F.

118. *Light Emitted by Continuous-Current Arc.* **Mrs. H. Ayrton.** (Electrician, 45. pp. 921–924, Oct. 12; and 966–967, Oct. 19, 1900. Abstract of a paper read before the International Electricity Congress at Paris.)—With constant current there is a definite length of arc at which the candle-power is a maximum; when the current exceeds 10 amperes there is also a minimum point, corresponding to a length of arc of about 2 mm., and there is another maximum point at about 1 mm. The last is shown to be due to the shape of the point of the negative carbon, which permits more light to escape from the crater when the arc is 1 mm. in length than when it is 2 mm. long. At the same time the efficiency is greater, and it is shown that no other length of arc is equally efficient. The ideal arc is exceedingly short, with a very sharp-pointed negative carbon. The increase in candle-power between the minimum point and the second maximum is due to the diminished screening by the negative carbon; but the subsequent diminution can only be due to absorption by solid particles of carbon and carbon vapour in the arc itself. This was proved by throwing the shadow of an arc upon a screen by means of a second arc; the same experiment showed that the arc is less dense than air, and acts as a negative lens. The increased absorption is caused by the greater condensation of carbon vapour between the carbons as the arc is lengthened. The absorption is shown to be selective, the carbon mist absorbing a larger proportion of the orange and green than of the violet rays. This explains the violet tint of the light emitted by the arc itself, the tendency of the light to become more violet as the arc is lengthened, and the diminution of the candle-power in the latter case. A. H. A.

119. *Cable Tests at High Voltages.* **J. Wright.** (Elect. Rev. 47. pp. 653–654, Oct. 26, 1900.)—The author thinks that a wire insulated with vulcanised rubber may show many hundred megohms when measured with 600 volts continuous pressure, and break down immediately under 600 volts alternating. Insulation should be taken immediately before and after high-pressure tests, and *no* diminution found. M. O'G.

120. *Measurement of Standard Resistances.* **R. T. Glazebrook.** (Phil. Mag. 50. pp. 410–416, Oct., 1900. Paper read before the Physical Society of London.)—This paper gives a description and comparison of four different methods of determining the resistances of coils of 10, 100, and 1,000 ohms. Each coil was determined by two or more methods, and the results show the accuracy that may be obtained without any very elaborate precautions. The

coils were all of platinum silver with a temperature coefficient of about 0·00028 per 1° C., and by far the most important source of error is the uncertainty of the temperature. In Method I. (which was that employed in constructing the standards of the British Association), three 3-ohm coils are wound on the same bobbin and adjusted to be as nearly equal as possible. By means of an arrangement of mercury cups these coils can be put in parallel or in series. If B is their resistance in parallel and B′ that in series, $B' = 9B$ very approximately.

Let U be the resistance of the short copper rods used to connect the system of coils to a Carey-Foster bridge, X the resistance of the 10-ohm coil to be found, and S the resistance of the standard ohm. The coils are first put in parallel and compared with S; let x be the shift on the bridge wire. Then $B + U = S + x$. Next S is placed in series with the three 3-ohm coils, which are also in series, and these are compared with the 10-ohm coil. In this case let x_2 be the shift on the wire. Then

$$X = 9B + U + S + x_2 = 10S - 8U + 9x + x_2,$$

so that if U is known, the value of X is found in terms of S.

The other methods are "built-up" ones. Five coils in series are enclosed in a box, their values being 1, 1, 2, and 4 units. The two ends of the whole series, and each junction of two consecutive coils, are connected to mercury cups.

Method II. The two unit coils of the box are separately compared with the standard by connecting it to a Carey-Foster bridge with contact pieces of known resistance. The other coils are found in terms of these, so that ultimately the value of the whole box is known in terms of the standard. The objection to this method is that it takes time, and temperature changes lead to difficulty.

Method III. This is a preferable method for boxes where the unit coil is greater than 1 ohm. Two 10-ohm coils, P and Q, have their difference accurately found by the Carey-Foster bridge; thus the ratio P/Q is accurately known. The value of the first unit coil of the box is also found on the Carey-Foster bridge. Four mercury cups, A, B, C, and D, are arranged at the corners of a square, the gaps A B, B C contain the coils P, Q respectively. The first unit coil of the box is connected to A and D, and the second to B and C. The resistances of the connecting-rods should be equal. A battery connects B and D, and a galvanometer A and C.

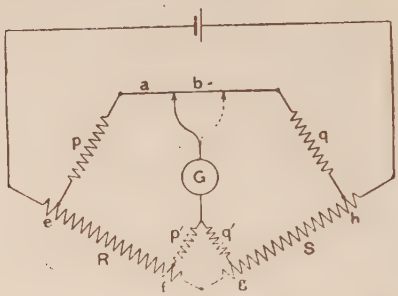
A balance is obtained by shunting P or Q with a resistance W, which need not be accurately known. Thus the second unit coil is obtained in terms of the first. These two in series are then compared with the 2-unit coil and so on. A table of comparisons of certain standard 10-ohm coils is given, each coil being determined by two at least of the above methods.

The difference between the values obtained for the same coil by two different methods does not exceed 0·00004 of the whole value, and in most cases is not greater than would be caused by an uncertainty of 0·1° C. in temperature, and no attempt was made to read the thermometers to a greater accuracy than this.

In the case of the 100 and 1,000-ohm coils Method III. was used; also a fourth method, viz., that ordinarily employed in testing such coils for the B.A. Committee. E. C. R.

121. *Improved Form of Carey-Foster Bridge.* **C. V. Drysdale.** (Electrician, 5. pp. 883–886, Oct. 5, 1900.)—This bridge is a combination of the secondary

conductors of the Kelvin double bridge with the Carey-Foster bridge, so as to adapt the latter for use in the measurement of very low resistances. For this purpose, in addition to connecting the secondary conductors or ratio coils across the junction between the resistances to be compared, the slide-wire is removed from its ordinary position between the coils whose resistances are to be compared, and introduced between the ordinary ratio coils as indicated in the figure.



In this arrangement, if x is the resistance between terminals f and g, including the contact resistance, and C_1 and C_2 the currents in the upper and lower branches respectively, we have

$$R+\frac{p'}{p'+q'}\left\{\frac{x(p'+q')}{p'+q'+x}\right\}=R+\frac{p'x}{p'+q'+x}=\frac{C_1}{C_2}(p+a),$$

and on interchanging R and S,

$$S+\frac{p'x}{p'+q'+x}=\frac{C_1}{C_2}(p+a+b);$$

hence—

$$R-S=\frac{C_1}{C_2}b.$$

A practical form of the bridge is described possessing the following novel features, viz.: (*a*) The copper connecting bars are all mounted *beneath* the ebonite base, and have mercury cups projecting through so as to be level with the upper surface of the ebonite; (*b*) the slide-wire is always connected between the ratio coils, thus reducing the number of contacts on the commutator to four; (*c*) the cups for the secondary conductors or ratio coils can be readily short-circuited so as to adapt the bridge for ordinary use; (*d*) the sliding contact is mounted on an arm which is pivoted at the other end.

C. K. F.

122. *Resistances of Platino-Silicium.* **V. Rodt.** (Elektrotechn. Zeitschr. 21. pp. 847-848, Oct. 11, 1900.)—The firm of W. C. Heraeus, of Hanau, has recently placed on the market resistances consisting of a thin layer of platino-silicium spread over a cylindrical core of clay (about 7·2 to 12·1 cm. long and 0·5 cm. in diameter). Originally these resistances were intended for electric heating appliances. The author's investigations show that they are wonderfully permanent, and are capable of withstanding exceedingly rough treatment. Heating to a high temperature in the flame of a Bunsen burner, exposure to the fumes of bromine for a period of eighteen hours, soaking for a long time in brine or in nitric acid, appeared to produce no perceptible change in the value of the resistance. Hence such resistances are particularly well adapted for use in all cases where the ordinary wire resistances are liable to be attacked by chemical agency. [See also Abstract No. 175 (1900).] **A. H.**

123. *Standard Resistance Coil.* **R. S. Whipple.** (Electrician, 45. p. 772, Sept. 14, 1900. Paper read before the British Association.)—The coil described is made of bare 0·035-inch platinum silver wire wound on mica frames, the ends of the wire being attached to stout copper terminals in the usual manner. A 0·008-inch platinum wire is wound alternately with the platinum-silver wire, and is also attached to stout copper leads. Both coils are adjusted to a resistance of 1 ohm at 15·5° C. Owing to the difference in the temperature coefficient in the two wires a small change in the temperature causes a comparatively large difference between the resistances of the two coils. From this difference the temperature may be determined from a table experimentally made up beforehand. The frame and wires are immersed in oil contained in a glass vessel. They are therefore at the same temperature, and since they are wound alternately no stirrer is necessary. The platinum wire is also useful for testing the insulation of the windings of the Pt-Ag coil one from the other. E. E. F.

124. *Construction of Standard Resistances.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. pp. 807–808, Sept. 27, 1900.)—The resistances here described are made of manganin heated for some time to 100° C. in steam-jacketed vessels to prevent subsequent alteration, and coated with shellac to protect them from the action of the atmosphere. The coils are wound on old maple bobbins saturated with shellac varnish and well dried before and after varnishing. The coils are provided with Uppenborn's correcting shunt as follows : The first, or main section, consists of a thick double silk covered wire treated with shellac and wound double, its ends being soldered with silver into metal plates mounted on one end of the bobbin. This wire is in one piece, and its resistance is about 1 per cent. higher than the standard. The shunt has its ends soldered with acid-free solder on to the plates and is more than 100 times the resistance of the thick wire. The inner part of this coil is divided and the ends screwed to a block on the lower end of the bobbin. The combined resistance is then adjusted to the normal value by means of the correcting coil, taking care not to cut off too much, as unsatisfactory results are obtained if joints are made. Each of the plates is joined to its respective plug-block by a separate pillar instead of joining the ends of two adjacent coils to a common pillar as heretofore, thus eliminating the error due to there being a varying number of these pillars in circuit according as consecutive resistances are in use or not. In calibrating, the plugs are inserted very tightly by means of keys similar to those used in tuning pianofortes, the plugs being made wholly of metal so as to resist the extra stress. By this means the resistance of thirty plug-joints in series is $\pm$ 0·00003 ohm with 7 mm. plugs; with 14 mm. plugs it is $\pm$ 0·000005 ohm. C. K. F.

125. *Cable Capacity Measurements.* **J. E. Young.** (Inst. Elect. Engin., Journ. 29. pp. 941–943, July, 1900.)—The "instantaneous" or "surface" capacity is a constant, and the "total" capacity depends on the time of charge. "Murphy's" method gives an intermediate or quasi-constant measure, but has been found best for securing uniformity of measurement. M. O'G.

126. *E.M.F. produced by Movement of Liquid.* **C. Zakrzewski.** (Accad. Sci. Cracovie, Bull. pp. 224–227, June, 1900.)—Water was caused, by means of compressed air, to pass from one vessel to another through a capillary glass

tube silvered inside. The length of the tube was about 15 cm., its diameter 0·2 mm. Two platinum electrodes covered with platinum black were placed opposite the ends of the capillary tube, and were joined to wires of the same metal, which passed outside and could be connected to a Thomson's astatic galvanometer. It was found that a flow of water was always accompanied by an electric current, whose direction depended on that of the water.

(1) The E.M.F. of this current was found to be proportional to the difference of pressures at the two ends of the capillary tube. In one series of observations the following numbers were obtained :—

Pressure in Atmospheres (P)	E.M.F. in Volts (E)	Ratio $\frac{E}{P}$
0·5	0·026	0·0052
0·6	0·031	0·0051
0·8	0·043	0·0054

(2) The E.M.F. depends on the distance between the electrodes and the ends of the capillary tube. Increasing the distance of the electrode in the vessel at lower pressure diminishes the E.M.F.

This result may be considered as a confirmation of the Quincke-Helmholtz hypothesis, which explains the origin of the E.M.F. by the disruption of the double electric layer situated at the surface of separation of silver and water. A second charge must be admitted in the layer of silver. If one of the platinum electrodes is taken away and the galvanometer directly connected to the layer of silver, an electric current is observed when the flow of water is directed towards the electrode. The E.M.F. diminishes as the electrode is moved farther away. If the flow of water is in the opposite direction the current is much more feeble. In this case nearly all the electrified particles are dispersed in the vessel, and it is only a very small number of them which pass through the tube and give up their charge to the layer of silver.

Sometimes, especially in tubes newly silvered, the E.M.F. undergoes sudden changes, rising from some thousandths to some tenths of a volt, or *vice versâ*. This is due to change of resistance of the tube and its contents. It may almost always be brought back to its original value by causing electric sparks to pass in the neighbourhood of the tube. The tube with the contained liquid behaves in this case like a coherer towards electric waves.

The E.M.F. becomes less as the thickness of the layer of silver is increased.

In experiments with water the electrode in the vessel at lower pressure is always positive, which shows that water in contact with silver has a positive charge. When a dilute solution of silver nitrate is used instead of water it is found that the sign of the charge of the solution depends on its concentration.

J. J. S.

127. *Resistance of Pressed Powders.* **F. Streintz.** (Ann. d. Physik, 3. 1 pp. 1–19, Sept., 1900. From the Akad. Wiss. Wien, Sitz. Ber. 109. IIa., April 1900.)—The distinction between metallic and electrolytic conduction is chiefly based upon the temperature coefficient of the resistance. If the resistance increases with the temperature, the conduction is metallic. If it decreases the conduction is electrolytic. Conductors belonging to both classes, or to an intermediate class, have not hitherto been obtained. But the author has made some experiments on powdered conductors which indicate something like a transition from one class to the other. He prepared fine powders of platinum black, graphite, and lampblack, and subjected them to considerable pressure in a hole bored in a block of ebonite, at the same time determining

heir resistance by auxiliary electrodes inserted in the block. The resistance of 1 mm. of platinum black having a section 1 mm. square was found to be 0·92 ohms at zero, as against 0·14 for ordinary metallic platinum. But the temperature coefficient of platinum black is only half that of platinum. Lampblack under the same conditions showed a resistance of 40,000 ohms, and a *negative* temperature coefficient amounting to the enormous value of 4 per cent. for 1° C. The column of lampblack is therefore equivalent to a dilute solution of sulphuric acid. Graphite, on the other hand, showed a resistance of only 21·9 ohms, and had a positive temperature coefficient. It therefore ranges itself among the metals in this respect. To complete the electrolytic character of lampblack, some kind of ionisation and consequent polarisation remains to be established. E. E. F.

128. *Measurement of Power in Inductive Circuits.* **E. Reisz.** (Elektrotechn. Zeitschr. 21. pp. 713–714, Aug. 23, 1900.)—The method involves the use of only two measuring instruments—a voltmeter and an ammeter—and a standard non-inductive resistance. In Fig. 1 the coiled line between A and B represents the inductive load. If V = P.D. between A and B, i = current, $\cos\phi$ = power-factor, then the power is given by $Vi\cos\phi$. By connecting in

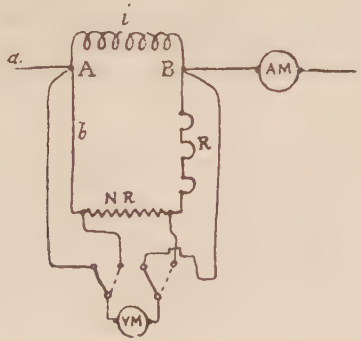


FIG. 1.

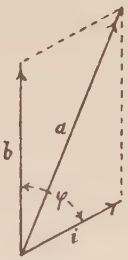


FIG. 2.

parallel with the inductive load a non-inductive resistance NR, we obtain the following relation (Fig. 2) between i, a, and b :—

$$a^2 = b^2 + i^2 + 2bi\cos\phi \qquad (1)$$

In order to find i, the shunting resistance is altered (the P.D. across AB being, however, maintained constant). Let the new values of a and b be denoted by a_1 and b_1. Then—

$$a_1^2 = b_1^2 + i^2 + 2b_1 i\cos\phi, \qquad (2)$$

so that i and $\cos\phi$ may be found from (1) and (2). The author remarks that the method may prove useful in cases where the power is so small that an ordinary wattmeter is not sufficiently sensitive, and where a reflecting wattmeter is not available. A. H.

129. *Mirror Form of Electro-dynamometer.* **J. Kollert.** (Elektrotechn. Zeitschr. 21. pp. 788–794, Sept. 20, 1900.)—This is an important paper on electro-dynamometers. It is divided into four parts, of which the first deals with the instrument as a wattmeter, the second as an ammeter, the third as a

voltmeter, the fourth shows the arrangement of an instrument adapted for either of these measurements. In the first part constructional details of a mirror form of wattmeter are given. It is shown that in order to adapt this instrument to general measurements of direct or alternate currents self-induction must be reduced. This implies a small turning moment, and consequently the use of a mirror. To provide a portable, self-contained instrument a telescope and scale is attached to the base-plate of the wattmeter. There are two "current" coils, each consisting of eight turns of manganin wire 1·5 mm. diameter; they are wound and set like the coils of a Gaugain-Helmholtz galvanometer, so as to provide a uniform field for the "e.m.f." coil, which hangs between them. The "e.m.f." coil consists of 260 turns of manganin wire 0·25 mm. diameter. The mean diameter of the suspended coil is 1·5 cm. Full details of the suspension and optical arrangements are given. The author then considers the problem of the error introduced by the employment of shunts, and he shows that even for high periodicities the self-induction of the instrument is so small that its readings are for all practical purposes correct. He can therefore deal with currents from 0 to 500 amperes by shunting. The correction coefficient for mutual induction between the coils, corresponding to differences of phase and frequency, are also calculated; it amounts to something like 0·5 per cent. in a moderate case. The effect of the earth's magnetism is considered. In the latter parts of the paper details of the windings and the range of measurement are given for ammeters and voltmeters of this form, as well as diagrams of the author's universal electro-dynamometer. R. A.

130. *Determination of Frequency in Liquid Interrupters.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 21. pp. 824–826, Oct. 4, 1900.)—The paper referred to in Abstract No. 2041 (1900) is extended by the useful introduction of drawings of the plan and elevation of the instrument used to find interrupter frequencies by the dust-heap method. The author is thus enabled to give a more detailed description of the apparatus. The lycopodium heaps produced at each current interruption arise from the same cause as Lichtenberg figures. A measurement of the e.m.f. across the interrupter terminals when driven at 110 volts showed an increase to 205 volts, the e.m.f. at the instant of break probably amounting to thousands of volts. In order to get good dust figures the self-induction of the circuit must not be too small. G. E. A.

131. *Power-factor Indicator.* **A. J. Bowie, Jr.** (Elect. World and Engineer, 36. pp. 644–645, Oct. 27, 1900.)—The instrument will read directly the angle of lag of current behind an e.m.f. E_1 when there are known the angles of lag, α and β, of E behind two other e.m.f.'s E_1 and E_2 and the ratio E_1/E_2. It consists of a wattmeter with two movable coils mounted on the same suspension and fixed relatively to one another at an angle ϵ. To measure the lag on two-phase systems, E_1 and E_2 being the two e.m.f.'s; $\alpha = 0$, $\beta = \pm 90°$ and $E_1 = E_2$; then if ϵ be made 90° the deflection of the movable system is dependent only on the angle of lag. On three phase systems, with triangular connection, E_1 and E_2 are taken as the e.m.f. on two sides of the triangle; then if ϵ be made 120° the indicator will read the angle of lag in the main from the junction of the two sides of the triangle representing E_1 and E_2, α and β in this case being each $= 30°$. On single phase systems an auxiliary out-of-phase e.m.f. must be produced by using an inductance, but in this case the readings will vary with the frequency. G. H.

132. *Current Manometer.* **G. Bredig** and **O. Hahn.** (Phys. Zeitschr. 1. pp. 561–562, Sept. 8, 1900.)—The authors have arranged a gas voltameter to measure the current passing through it by the rate of evolution of gas. A voltameter filled with 2 per cent. caustic solution is provided with only a capillary outlet for the gas, and a water pressure gauge is connected with the voltameter cell. The rate of evolution of gas, which is proportional to the current, is also proportional to the pressure produced by the restricted outlet of the capillary tube, and the current is therefore proportional to the readings of the water gauge.

The sensibility can be varied within very wide limits by using capillary tubes of different bores. The authors' tests show an accuracy of about 2 per cent. G. H. B.

133. *Limiting Deflection of a Quadrant Electrometer.* **A. B. Chauveau.** (Journ. de Physique, 9. pp. 524–532, Oct., 1900.)—In measuring high potentials with the quadrant electrometer, whose sensitiveness is reduced by the employment of a heavy needle and a considerable distance between the wires of the bifilar suspension, it is found that after a certain difference of potential the sensitiveness decreases rapidly, and that the deflection attains a value beyond which it cannot go. The author points out that the existence of this limiting deviation is due to the impossibility of practically realising a perfect symmetry of the system formed by the quadrants and the needle, and to the existence of a disturbing electric couple which is proportional to the square of the difference of potential between the quadrants. The author studies, theoretically and practically, the influence of various modifications of the suspension upon the limiting deflection, and shows that, by a careful construction, the limit can be pushed back almost indefinitely, so that the deflections in one direction at all events should show no serious falling off in the sensitiveness for the higher e.m.f.'s. With his own instrument, which is now installed for use at the Eiffel Tower Observatory, he has thus succeeded in measuring voltages as high as 2,000, or even higher. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

134. *Skin Effect and Distribution of Currents in Squirrel-Cage Rotor.* **R. Goldschmidt.** (Écl. Électr. 25. pp. 76–83, Oct. 13, 1900.)—The author deals with three alternate-current problems which have already received solutions, but only by the aid of somewhat advanced methods; and offers simple approximate methods of dealing with them. The first problem is that known as the "skin effect," and has reference to the unequal distribution of an alternating current over the cross-section of a conductor. It is assumed that the conductor is a circular cylinder, and that it is so far removed from other conductors that the field in the substance of the conductor is a symmetrical one, the lines of induction being a series of concentric circles. Imagine the conductor split up into a number of hollow concentric cylindric shells of equal thickness. Let e stand for the instantaneous p.d. across the ends of the conductor, and let r_n, r_{n+1} and i_n, i_{n+1} stand for the resistances of, and instantaneous currents in, the nth and $n+1$th shells respectively. Then (see Fig. 1) we have $i_{n+1} r_{n+1} - i_n r_n =$ total resultant e.m.f. round circuit shown by dotted lines. But if F_n and F_{n+1} stand for the total number of

lines of induction linked with the nth and $n+1$th shells respectively, then—

$$i_{n+1}r_{n+1} - i_n r_n = \left(e - 10^{-8}\frac{dF_{n+1}}{dt}\right) - \left(e - 10^{-8}\frac{dF_n}{dt}\right) = \frac{d(F_n - F_{n+1})}{dt}\cdot 10^{-8}.$$

Or, if we denote $F_n - F_{n+1}$ (the magnetic flux through the dotted line in Fig. 1) by f_{n+1},

$$i_{n+1}r_{n+1} - i_n r_n = \frac{df_{n+1}}{dt} \times 10^{-8} \qquad (1)$$

Now if R_{n+1} stand for the magnetic reluctance of the path corresponding to the flux f_{n+1}, we have

$$f_{n+1} = \frac{4\pi}{10}\cdot\frac{I_{n+1} + 0{\cdot}25i_{n+1}}{R_{n+1}},$$

where $I_{n+1} = i_1 + i_2 + \ldots + i_n$. Substituting this value in equation (1), and putting, for the sake of brevity,

$$c_1 = \frac{r_n}{r_{n+1}}, \quad c_2 = \frac{4\pi}{10}\cdot\frac{10^{-8}}{R_{n+1}r_{n+1}},$$

we get—

$$i_{n+1} = c_1 i_n + c_2\frac{dI_{n+1}}{dt} + \frac{c_2}{4}\frac{di_{n+1}}{dt} \qquad (2)$$

Next assume that all the quantities are simple sine functions of the time, and put $i_n = A_n \sin pt$, $I_{n+1} = S_{n+1}\sin(pt+\alpha)$, $i_{n+1} = A_{n+1}\sin(pt+\beta)$, then (2) becomes

$$i_{n+1} = c_1 A_n \sin pt + pS_{n+1}\cos(pt+\alpha) + \frac{pc_2}{4}A_{n+1}\cos(pt+\beta),$$

and we are now, by means of the vector diagram shown in Fig. 2, able to find i_{n+1} when i_n and I_{n+1} are known.

In applying this method we commence with the central cylinder, assuming

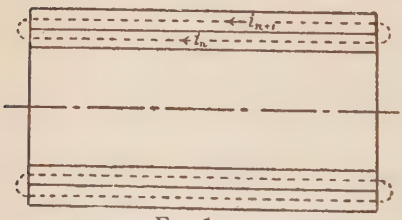


FIG. 1.

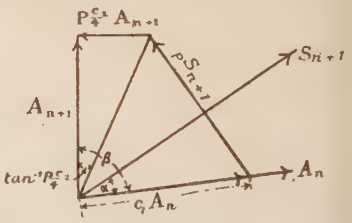


FIG. 2.

arbitrarily any current (say unity) for it. We then find, by the vector diagram of Fig. 2, the current in the neighbouring cylindric shell. Proceeding step by step, we construct a diagram giving the relative amplitudes and phases of the currents in the various shells. From this the resistance of the cylindric conductor to the alternating current is easily found.

The second problem considered by the author is the screening effect due to eddy currents in plates and solid masses of iron. The treatment follows closely the method just explained for dealing with the unequal distribution of a current over the cross-section of a conductor. The last problem is concerned with the distribution of the currents in a squirrel-cage rotor when the impressed rotating field has a simple sine distribution in space. A. H.

135. *Impedance of Iron Conductors.* **C. Feldmann** and **J. Herzog.** (Elektrotechn. Zeitschr. 21. pp. 844–847, Oct. 11, 1900. Also Abstract in Elect. Engin. 26. pp. 741–743, Nov. 23, 1900.)—After referring to the work of Rayleigh and Kelvin on the distribution of an alternating current over the cross-section of a conductor, the authors point out that the series given by these writers for the equivalent resistance of the conductor, are very slowly convergent when the permeability has a high value, and that it is more convenient in such cases to have recourse to the formulæ of J. J. Thomson, for the actual magnetic intensity at any point of a lamina of iron which is subjected to an alternating impressed magnetic field. These formulæ will apply to the distribution of an alternating current over the cross-section of a lamina, and it is convenient to determine the depth of the effective surface layer which represents the equivalent resistance. Curves are given for this depth corresponding to different thicknesses of the lamina and different frequencies. The authors next give the results of some experimental determinations of the impedance for iron conductors of various forms of cross-section. The subject is of importance in connection with polyphase systems of electric traction using a rail return. An account of some further experiments with steel rails is given, which shows that the impedance varies considerably with the shape of the p.d. wave, a peaked wave producing a much higher impedance than a sine wave. Wattmeter measurements showed that the power factor was in all cases in the neighbourhood of 0·8. The authors point out that with alternating currents the efficiency of rail bonds is relatively less important, on account of the greatly increased impedance of the rails; the experiments alluded to above showing that with a frequency of 42 the impedance was 5·25 times, and with a frequency of 15, 3·6 times, the resistance to continuous currents. The importance of using the lowest practicable frequency in connection with traction systems is sufficiently obvious. A. H.

136. *Influence of Magnetism on Chemical Reactions.* **A. de Hemptinne.** (Zeitschr. Phys. Chem. 34. pp. 669–682, Sept. 18, 1900.)—The author applies the laws of thermodynamics to the study of the influence of magnetism on chemical equilibrium, and finds that even under the most favourable conditions such influence is too small to be measured. For example, the change in the heat of solution of iron in dilute hydrochloric acid brought about by a magnetic field of 10,000 units would be about 0·13 per cent. To determine the influence of magnetism on the velocity of chemical reactions, the hydrolysis of methyl acetate, the inversion of cane sugar, the action of acids on iron, and the union of hydrogen and chlorine have been studied both within and without a magnetic field. The differences between the results of the two series of experiments lie within the limits of experimental error. T. H. P.

137. *Magnetic Susceptibility and Atomic Volume.* **S. Meyer.** (Phys. Zeitschr. 1. pp. 433–434, July 7, 1900.)—Against Errera's contention that the magnetic susceptibility of the elements can at present only be regarded as a periodic function of the atomic weight, and cannot be brought into relation with the atomic volume [see Abstract No. 1314 (1900)], the author maintains that the relation established by himself is not only without irregularities, except in the case of carbon, but brings the susceptibility into connection with the melting-point, the hardness, and other properties depending upon the aggregation of the atoms in space. The strongly magnetic elements find their places in the minima of the curve of atomic volume, and in the portions preceding the minima. The diamagnetic substances are found grouped

about the maxima, the extremes being somewhat displaced towards the lesser atomic weights. The secondary minima are associated with feebly diamagnetic or even paramagnetic bodies. Carbon and zirconium are diamagnetic, although they stand in the even series of Mendelejeff's table, and the diamagnetic character of Li, Na, K, Rb, Cs, Ca, Sr, and Ba renders it impossible to regard the atomic susceptibility as a periodic function of the atomic weight. E. E. F.

138. *Change of Magnetic Moment by Shocks.* **K. Krüse.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 195–213, Jan.–March, 1900.)—The bar magnets of Klemenčič [Abstract No. 1867 (1900)] are subjected to violent treatment, and the resulting change of magnetic moment measured. The shocks are produced in three ways: first, by letting the magnets fall down vertical brass tubes, of different heights, on to a marble slab; second, by moving the magnets up to make contact with a soft iron bar, then tearing the magnet off; third, by placing the magnet on the centre of a soft iron plate and then drawing it off lengthwise. Fifteen tables of the results of these treatments are given. Among other things, it is found, in bumping the magnets, that the greatest decrease is after the first fall, and that only in isolated cases does the moment remain unchanged after frequent falls from the same height. The total decrease of moment varies between 1·6 per cent. and 25·6 per cent. The changes due to pulling the magnets from contact with a soft iron bar are very slight, being an increase after the first separation, changing to a decrease after ten separations. Drawing a magnet off a soft iron plate sometimes diminishes its moment 28 per cent. G. E. A.

139. *Constancy of Permanent Magnets.* **I. Klemenčič.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 242–275, April, 1900.)—Observations extending over a year were made with steel bars obtained from makers in Vienna, Zurich, Hagen, Berlin, and Paris, but chiefly with forty magnets of Wolfram steel of five different kinds made by Böhler. The bars were magnetised in a homogeneous field of 600–700 c.g.s. and were, after magnetisation, put into boxes in the E—W position. Comparisons were made by measuring the deflections of a magnetometer needle due to the various magnets, to a constant current in a manganin coil, and to two "normal" magnets magnetised in 1896. Tables appended show that: (*i*) The decrease of magnetic moment with time varies in the reverse direction with the dimension ratio [Abstract No. 1867 (1900)]; (*ii*) In the first days after magnetisation the thin magnets hold their magnetism best.

A classification of the magnets according to their quality, made after fifteen months' observations, is quite different to one made three weeks after magnetisation; and further, the former classification is almost the opposite of one made by Krüse (see preceding Abstract) for the same magnets; *e.g.*, those which, under undisturbed conditions, come in the order 1, 2, 3, 4, 5, (Klemenčič), are, in order of ability to withstand shocks, 5, 3, 4, 1, 2 (Krüse). Magnets with small coercive forces give the best results in undisturbed conditions. G. E. A.

140. *Magnetic Moment of Magnets and Temperature.* **M. Prodinger.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 383–399, May, 1900.)—The temperature coefficient of the magnetic moment of magnets is here experimentally investigated and is found to vary with the linear dimensions, with the magnetic moment, and with the specific electrical resistance.

The results lead to the following conclusions : The specific resistance, which has a considerable influence on the magnitude of the temperature coefficient, appears to have no influence on the relationship between the temperature coefficient and the magnetic moment. Two conditions seem to control the relationship between the temperature coefficient and the magnetic moment ; these are the ratio of length to thickness and the thickness. In magnets whose length is great compared with the thickness (23 to 27 times), and whose thickness is small (4 mm. to 7·3 mm.), the temperature coefficient increases considerably with the magnetic moment. In magnets of about the same thickness as above (5·37 to 6·95 mm.), but whose length is less (10·03 to 10·79 times the thickness), the increase in temperature coefficient due to increase in magnetic moment is much less. In magnets with a small ratio of length to thickness (10·14 and 6·52) and of considerable thickness (9·86 to 9·20), the temperature coefficient no longer varies with the magnetic moment but is constant. J. B. H.

141. *Magnetisation of Iron Filings mixed with Ferro-Manganese.* **E. Wilson.** (Electrician, 45. pp. 894–896, Oct. 5, 1900.)—The filings, mixed with 17 per cent. by weight of ferro-manganese powder, containing 85 per cent. manganese, were placed in a hollow cylinder of asbestos, wound with exciting and exploring coils. From experiments it was found that the ferro-manganese diminishes the hysteresis of the filings, after heating to about 900° C., and the increase in permeability, observed after heating simple filings to that temperature, is greatly reduced. W. H. E.

142. *Bar Magnets.* **C. Chistoni.** (N. Cimento, 12. p. 37, July, 1900. From Mem. R. Accademia di Modena, serie 3, vol. 3.)—Solid steel bars have a higher permeability than hollow bars, probably owing to the fact that the former have only one tempered surface, while the latter have two. Bars which present thermal anomalies also present anomalies with respect to permeability. E. E. F.

143. *Permanent Magnets.* **C. Chistoni** and **G. G. de Vecchi.** (N. Cimento, 12. pp. 39–42, July, 1900. Mem. R. Accad. di Modena, serie 3, vol. 2, pp. 125–272.)—In this part of their work the authors examine the behaviour of steel magnets containing tungsten, and of other magnets when subjected to various tempering, hardening, and annealing processes. They do not arrive at a definite judgment concerning Barus' and Strouhal's process of magnetisation. E. E. F.

144. *Magnetic Effect of Electric Convection.* **V. Crémieu.** (Comptes Rendus, 131. pp. 797–800, Nov. 12, 1900.)—To confirm his previous negative result [see Abstract No. 1666 (1900)], the author has repeated the experiments of Rowland and Himstedt, who claimed to have shown the generation of a magnetic field by a moving electric charge. An ebonite disc, covered over with gilt sectors, was mounted inside a hollow wheel. The interior of the wheel was lined on both sides of the ebonite with brass, covered with sheets of mica, on which were stuck sectors of tinfoil. An astatic magnetic needle was used for detecting any magnetic field created by the revolution of the ebonite disc when the disc and the brass lining were given opposite charges. No deflection was observed, and thus Rowland and Himstedt's positive result is directly contradicted. But there is an important difference of detail in the

arrangement, for the latter stuck the tin-foil sectors on glass and had no brass lining. When the latter is removed a deflection is actually obtained, but it remains far inferior to what should be expected if the charges on the moving sectors were equivalent to a current. The author attributes it to small impulsive currents which are produced in the tin-foil sectors as the gilt sectors pass them. These impulsive currents are absorbed when the brass lining is introduced, or rather they induce opposite currents in the latter which neutralise the effect upon the astatic needle. E. E. F.

145. *Influence of Magnetisation upon Torsion.* **K. Schreber.** (Phys. Zeitschr. 2. pp. 18–20, Oct. 13, 1900.)—From the ample material supplied by Grösser (Rostock, 1894) the author has unravelled the following relations between magnetisation and torsion: Every iron or steel wire free from torsion acquires a permanent twist under magnetisation, which, with increasing field intensity, tends towards a maximum. The direction of the torsion is, strange to say, independent of the direction of magnetisation. In fact, it is reversed several times in the same wire as the field increases in strength. In iron the previous history of the wire does not seem to affect the amount of the twist, but in steel it does, to an extent which cannot as yet be stated in a simple manner. Moreover, the permanent twist is greater in steel than in iron. Besides the permanent twist, the wire experiences a temporary twist, which increases with the field as soon as the permanent twist has attained its maximum. Beyond that maximum, also, the temporary twist has always the same sign. An eye looking along the lines of force would always see the twist taking place in the direction of the hands of a watch. This practically diminishes the torsional elasticity in that direction. E. E. F.

146. *Trend of the Horizontal Component of the Earth's Magnetic Field in France.* **E. Mathias.** (Comptes Rendus, 131. pp. 554–556, Sept. 24, 1900.)—The author has made a magnetic survey of the neighbourhood of Toulouse, and finds that if ΔH is the difference between the value of the horizontal component at a given station and that at Toulouse, while Δ long. and Δ lat. are respectively the differences between the longitude and latitude of the station and Toulouse, then $\Delta H = -1{\cdot}26\ (\Delta \text{ long.}) - 7{\cdot}42\ (\Delta \text{ lat.})$. This expression seems to hold also for the rest of France, as shown by the observations of Moureaux. W. W.

REFERENCES.

147. *Models for the Electric Discharge in Gases.* **A. Garbasso.** (Phys. Zeitschr. 2. pp. 49–52, Oct. 27, 1900.)—A description of two models designed to illustrate the mechanism of the phenomena of electric discharge in gases investigated by Hertz, E. Wiedemann and H. Erbert, A. Sella and Q. Maiorana. E. H. B.

148. *Simple Relay for Experiments with Electric Waves.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 2. pp. 3–4, Oct. 6, 1900. Also Zeitschr. f. d. physikalischen u. chemischen Unterricht, xiii., Heft. 5.)

149. *Resistance of Bismuth in a Magnetic Field.* **W. Eichhorn.** (Ann. d. Physik, 3. 1, pp. 20–42, Sept., 1900.)—Paper similar to Abstract No. 1301 (1900).

150. *Magnets for Magneto-Optics.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. p. 794, Sept. 20, 1900.)—A description of a few convenient forms of electromagnets for research in magnetism and electro-optics. R. A.

151. *Standard Cells.* **J. Henderson.** (Elect. Engin. 26. pp. 121–124, July 27, and 155–158, Aug. 3, 1900.)—A general description of standard cells, and a *résumé* of recent research. W. R. C.

152. *Solution of Problems Involving Mutual Inductance by Vector Methods.* **J. Herzog** and **C. P. Feldmann.** (Elektrotechn. Zeitschr. 21. pp. 307–309, April 19, 1900.)—The authors use the well-known method in which a resistance and a reactance are represented by two mutually perpendicular vectors, and apply it to the solution of various problems involving mutual as well as self-inductance. A. H.

153. *Graphical Methods Applied to Problems in Polyphase Distribution.* **F. Blanc.** (Elektrotechn. Zeitschr. 21. pp. 733–735, Aug. 30, and 749–752, Sept. 6, 1900.)—The following is the problem considered by the author: Given three conductors maintained at given alternating p.d.'s, and having three inductive loads, of known impedance and power-factor, connected to them star-fashion, to find the currents taken by the star-connected circuits and the p.d.'s between the neutral point and each of the three-line wires. The author solves this problem by a graphical method, and illustrates the solution by working out a number of numerical examples. A. H.

154. *Skin Effect in Iron Wires.* **B. Hopps.** (Electrician, 45. p. 920, Oct. 12, 1900.)—The author gives tables and curves containing the results of some experiments on the impedance of iron rods (varying from 0·105 inches to 0·975 inches in diameter) to alternating currents. No attempt is made to separate the true resistance component of the impedance from the reactance component. A. H.

155. *Contact Methods of Determining Wave-Shapes.* **F. Niethammer.** (Elektrotechn. Zeitschr. 21. p. 309, April 19, 1900.)—A brief discussion of the various sources of error which may arise in connection with the different arrangements which may be used for determining wave-shapes by means of "contact" or "point" methods. A. H.

156. *Laboratory Instruments in the German Section of the Paris Exhibition.* **H. Armagnat.** (Écl. Électr. 24. pp. 321–334, Sept. 1, 1900.)—A very full description of some new electrical testing instruments, galvanometers, electro-dynamometers, resistances, potentiometers, ammeters for large currents, &c., exhibited by the principal German firms. E. K S.

157. *Magnetic Elements at Falmouth.* **E. Kitto.** (Roy. Soc., Proc. 67. pp. 139–158, Oct. 26, 1900.)—The mean hourly readings of the declination and horizontal force magnetographs for five "quiet" days in each month of the years 1897, 1898, and 1899 are given; also the hourly means of the vertical force for 1898. W. W.

158. *Measuring Instrument for Electrochemical Lecture Experiments.* **W. L. Miller** and **F. B. Kenrick.** (Journ. Phys. Chem. 4. pp. 599–618, Oct., 1900.)—A measuring instrument is described, which is provided with a dial 2 feet in diameter is dead-beat, reads directly ohms, megohms, volts, and amperes, their multiples and submultiples, and can be changed from any one of these uses to any other without delay. Fifteen examples are given for the use of the instrument for quantitative lecture experiments in electro-chemistry. T. M. L

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

159. *Action of Bromine on Phenylsulpho-acetic and α-Phenylsulphopropionic Acids.* **L. Ramberg.** (Zeitschr. Phys. Chem. 34. pp. 561–592, Sept. 7, 1900.)—The reaction between bromine and phenylsulpho-acetic acid in aqueous solution takes place in several phases, the first two, the products of which are mono- and dibromophenylsulpho-acetic acids respectively, having velocities approximately in the ratio 1·6 : 1. With α-phenylsulphopropionic acid, however, the action of bromine is one of simple substitution. In both cases, if the dilution is great, the velocity of the reaction is very nearly proportional to the product of the concentrations of the bromine and acid, whilst with more concentrated solutions it varies approximately as the product of the concentration of the acid and the square root of that of the bromine. The relative velocity increases with the dilution. T. H. P.

160. *Composition of the Surface-Layers of Aqueous Solutions.* **J. v. Zawidzki.** (Zeitschr. Phys. Chem. 35. pp. 77–80, Oct. 5, 1900.)—In order to study the distribution of a dissolved substance in the interior and in the surface-layers of a solution, aqueous hydrochloric and acetic acids were each mixed with such proportions of saponin as yielded solutions which on shaking formed a permanent froth. A current of air bubbles was passed through these liquids, the froth thus formed being condensed. The relative concentrations of the acid in the original liquid and in the condensed froth are found to be 33·50 and 33·61 for the acetic acid, and 20·03 and 20·19 in the case of hydrochloric acid. This change in concentration of the froth is due partially, but not entirely, to evaporation, which would, however, influence the results in opposite senses for the two acids employed. The author further finds that if air is passed through a saponin solution, and the foam removed as it is formed, after a certain time foam production ceases, whilst the liquid obtained by condensing the foam possesses in increased measure the capacity of forming foam. If alcohol be gradually added to an aqueous saponin solution, a point is reached when the liquid refuses to yield froth when shaken, while the subsequent addition of a few drops of water restores the frothing. Solutions of isobutyric acid do not give foam even when considerable proportions of saponin are present, but on neutralising the acid with a base the liquid readily froths. T. H. P.

161. *Action of Heat on the Absorption Spectra and Chemical Constitution of Saline Solutions.* **W. N. Hartley.** (Roy. Dublin Soc., Trans. 7. pp. 253–312, Sept., 1900.)—Descriptions and measurements are given of the absorption spectra of various metallic salts, and the changes produced in these when the temperature is raised are also described. The principal salts investigated were those of nickel, copper, cobalt, chromium, uranium, and didymium, and also potassium permanganate. The following are the conclusions reached by the author as to the molecular constitution and dissociation phenomena of saline solutions : (1) When a definite crystalline hydrate dissolves in a solvent which is not water, and is without chemical action upon it, the molecule of the salt remains unchanged in chemical composition. (2) In any series of salts which are anhydrous, and which do not form well-defined crystalline hydrates, the action of heat up to the temperature of 100° C. does not cause any

urther alteration in their absorption spectra, beyond that which is usual with bstances which undergo no chemical change by such rise of temperature. he change is usually an increase in the intensity of the absorption, or a slight idening of the absorption bands. (3) As a rule crystalline metallic salts in hich water is an integral part of the molecule, dissolve in water at ordinary mperatures, without dissociation of the molecule. (4) Crystallised hydrated alts dissolved in a minimum of water at 20° C. undergo dissociation by rise of mperature. The extent of the dissociation may proceed as far as complete ehydration of the compound, so that more or less of the anhydrous salt may e formed in the solution. (5) The most stable compound which can exist in saturated solution at 16° or 20° is not always of the same composition as the olecule of the crystallised solid at the same temperature, since the solid may ndergo partial dissociation from its water of crystallisation when the molecule nters into solution. (6) Saturated solutions of deliquescent salts combine ith water when diluted to constitute molecules of more complex hydrated ompounds in such solution. (7) When a saturated solution of a coloured alt undergoes a great change of colour upon dilution, or any remarkable hange in its absorption spectrum due to the same cause, the dilution is lways accompanied by a considerable evolution of heat. J. J. S.

162. *Adsorption of Gases by Glass Powder.* **P. Mülfarth.** (Ann. d. hysik, 3. 2. pp. 328–352, Oct., 1900.)—Considerable quantities of CO_2 are dsorbed even by perfectly dry glass powder. The adsorption increases ith falling temperature and with increasing pressure. It reaches a limit in ne or two hours. The adsorption is delayed by moisture, but is completed a few days. The quantities adsorbed are not even approximately as large s they should be according to Bunsen's experiments with glass threads. The llowing is the series of gases examined, arranged in the order of increasing dsorption: C_2H_2, N_2O, CO_2, SO_2, and NH_3. Bunsen's "capillary absorption" does not hold good for glass powder. Henry's law of absorption holds ery approximately good for the adsorption of gases by glass powder.

E. E. F.

163. *Periodic Phenomena in the Solution of Chromium in Acids.* **W. stwald.** [Zeitschr. Phys. Chem. 35. pp. 33–76, Oct. 5, and 204–256, Oct. 16, 900. From the Abhandl. d. K. S. Gesellsch. d. Wissenschaft., math.-phys. l. (4) 25 (1899) and 26 (1900).]—This long paper is devoted to a minute and etailed study of the behaviour of chromium on the lines already laid down in previous paper [Abstract No. 1513 (1900)]. An apparatus is described hereby the periodic changes in the velocity of solution are automatically ecorded, and a large number of diagrams are given showing the influence of mperature, concentration, and the presence of salts and other substances. he paper is not adapted to useful abstraction. The results described are of preliminary character, and it would seem that still further research is ecessary before any definite conclusions as to the cause of the periodicity an be arrived at. N. L.

164. *Diffusion of Gold in Solid Lead at Ordinary Temperatures.* **W. Roberts-Austen.** (Roy. Soc., Proc. 67. pp. 101–105, Oct. 26, 1900.)—ontinuing the experiments on diffusion described in the Bakerian lecture of 896, certain pure lead cylinders, each with a smooth surface at its base, lamped into close contact with the clean surface of a disc of gold, and so aintained undisturbed at a temperature varying but little from 18° C., were

examined after four years of such contact. Successive slices were cut at right angles to the axes of the cylinders, the first being about 0·75 mm. thick and each of those succeeding it about 2·3 mm. thick. Assays of these slices showed that those in contact with the gold had absorbed a quantity equivalent to about 1 oz. 6 dwt. of gold per ton of lead, whilst the next layers contained less, the next still less, and so on, the amount even in the poorest layer being in the proportion of 1½ dwt. per ton. The results shown by different experiments were not identical (probably because of the difficulty in ensuring perfect contact between the gold and the lead surfaces) but were all of the same order. The importance of temperature in relation to diffusion is shown by the fact that the amount of gold that would diffuse in solid lead at the ordinary temperatures in 1,000 years is the same as that which would diffuse in molten lead in a single day. Preliminary experiments, in which a current of 1·5 amperes was passed continuously through the clamped joint for 544 hours at 150°, seem to show that a solution of gold in lead does act to a small extent as an electrolyte. The failure of the author, in 1887, to obtain indications of electrolysis in a solution of gold in molten lead by the passage of a current of 300 amperes may have been due to the distribution of the precious metal by diffusion through the mass at the high temperature of the experiment. W. G. M.

165. *Action of Copper-Zinc Alloys on Nitric Acid.* **J. H. Gladstone.** (Phil. Mag. 50. pp. 231–237, Aug., 1900. Paper read before the Physical Society, May 11, 1900.)—The author shows by experiments that the alloys give much more nitrous acid and very much less ammonia than the corresponding mixtures. These results affect seriously the experiments made by Galt and by Baker to determine the heat of formation of copper-zinc alloys, in which it was assumed that the end state was the same whether one started with the alloy or the mixture. F. G. D.

166. *Alloys of the Gold-Copper Series.* **W. Roberts-Austen** and **T. K. Rose.** (Roy. Soc., Proc. 67. pp. 105–112, Oct. 26, 1900.)—The eutectic alloy of gold and copper appears to be that containing 18 per cent. of the latter metal, the melting-point of the alloy being about 905° C. (the fusing-points of pure gold and pure copper being respectively 1,063° C. and 1,083° C.). This proportion is equivalent to 60 atoms of gold to 40 atoms of copper, and is therefore the same as the atomic proportion of the silver-copper eutectic. Unlike most other eutectics (but like that of copper-silver) the gold-copper eutectic is brittle, breaking under a load of 7·87 tons per square inch with an elongation of only 3·3 per cent. In the limited mutual solubility of the two metals, and in the liquation which attends solidification, the gold-copper and silver-copper series of alloys also resemble each other closely. Copper appears, however, to be more soluble in gold than in silver, so that the characteristics of the gold-copper alloys are less marked, and consequently less easy to detect. Liquation, which is so marked in the case of standard silver (in which the precious metal tends to segregate to the centre) is observable, but to a much less extent in standard gold, in which case, however, the outside is usually found to be richer in gold than the inside. W. G. M.

167. *Passive State of Metals.* **W. Hittorf.** (Zeitschr. Elektrochem. 7 pp. 168–170. Discussion, pp. 170–171, Oct. 11, 1900. Paper read before the Deutsche Elektrochem. Gesell. Zurich.)—The close resemblance between the passive state of iron and of chromium shows that the former can scarcely be

due to a film of oxide protecting the metal. When chromium assumes the passive state it dissolves as chromic acid if the anion contains oxygen or can attack the water and liberate oxygen. Iron does not dissolve under these conditions, since ferric acid is unstable, but bubbles of oxygen are liberated and the iron behaves as a noble metal; **Strasser**, however, points out in the discussion, that when a fused alkali is used as electrolyte the iron dissolves, probably as potassium ferrate. The passive state of iron is rendered more stable by contact with an electronegative metal or a peroxide, but is instantly destroyed by contact with an electropositive metal like zinc, which converts it into a kathode. [See also Abstract No. 2283 (1900).] T. M. L.

168. *Hydrolysis of Ferric Chloride.* **H. M. Goodwin** and **F. W. Grover.** (Phys. Rev. 11. pp. 193–214, Oct., 1900.)—This paper is a continuation of a former one by Goodwin (Phys. Rev. 9. p. 251, 1896) and describes experiments on the influence exerted by change of temperature, by a magnetic field and by the presence of colloidal ferric hydroxide on the hydrolysis of ferric chloride; as in the previous work, the extent of hydrolysis is determined by measuring the electrical conductivity of the solution. It is found that a depression of temperature is accompanied by a diminution in the velocity of the reaction, by an increase of the initial lag, that is, of the period elapsing before hydrolysis begins, and also by an increase in the time required for a state of equilibrium to be attained. Lowering the temperature further tends to greatly diminish the separation of the oxychloride from solutions of ferric chloride. The addition of colloidal ferric hydroxide to the chloride solutions causes the hydrolytic action to be accelerated to an extent approximately proportional to the amount of the added hydroxide; this confirms the view that the hydrolysis occurring in ferric chloride solutions is due to the gradual formation of colloidal hydroxide from the ionised chloride. The reaction seems to be unaffected by a magnetic field. T. H. P.

169. *Gaseous Solutions Physically and Chemically Supersaturated.* **Berthelot.** (Comptes Rendus, 131. pp. 637–646, Oct. 22, 1900.)—On carefully mixing hydrogen peroxide and potassium permanganate in suitably dilute solutions and in presence of an excess of sulphuric acid no evolution of oxygen takes place; gas is, however, given off on agitating the liquid or on adding some powdered material such as spongy platinum. The author describes experiments carried out to determine whether such solutions are merely supersaturated with respect to the oxygen or whether an unstable highly oxygenated compound is present. From a comparison of the changes of temperature of the mixture before and after evolution of oxygen with those of a similar liquid from which the gas has already been removed by shaking, the author arrives at the conclusion that the oxygen is present in the form of an unstable compound other than hydrogen peroxide, and that heat is developed by the decomposition of this compound. T. H. P.

170. *Crystallography of the Double Selenates, $R_2Zn(SeO_4)_2.6H_2O$.* **A. E. Tutton.** (Roy. Soc., Proc. 66. pp. 248–250, April 14, 1900, and 67. pp. 78–84, Oct. 3, 1900.)—This paper contains results of a detailed comparative study of the morphological and physical properties of the mono-symmetric crystals of the double selenates of the composition $R_2Zn(SeO_4)_2.6H_2O$, where R represents K, Rb or Cs. It is found in all cases that the morphological properties and also the whole of the specific and molecular optical constants of rubidium-zinc selenates occupy an intermediate position between those of the potassium and cæsium zinc salts. Comparison with the

results formerly obtained for the analogous double zinc sulphates shows tha replacement of sulphur by selenium is generally accompanied by a change i the morphological and physical constants similar to that produced by th replacement of one alkali metal by another of higher atomic weight. T. H. R

171. *Vapour Pressures of Fluid Mixtures.* **J. v. Zawidzki.** (Zeitschr Phys. Chem. 35. pp. 129–203, Oct. 16, 1900.)—The author describes a serie of experiments undertaken primarily in order to verify the relation determine by Margules between the partial pressures of its two constituents and th composition of a fluid mixture. A modified form of Lehfeldt's apparatus wa employed, the vessel in which the mixture was boiled being of about 200 c.c capacity, and being boiled on a thermostat maintained at a temperature 1 above the boiling-point of the mixture. Steady ebullition was ensured b passing an electric current through a pair of thick copper wires dipping i the liquid and connected at their extremities by a small piece of thin platinum wire; previous experiments proved that this caused no chemical change i the liquid. The vapours given off by the boiling liquid were condensed in vessel surrounded by melting ice; connections with the condenser were s made that, when a sufficient quantity of the distillate was collected, it coul be removed without disturbing the rest of the apparatus. The condense and boiler were in communication, by means of a tube furnished with a stop cock, with a vessel in which the pressure could be regulated and measured.

A series of experiments was conducted as follows: One liquid was place in the boiler and its vapour pressure determined at the required temperature a small quantity of the second liquid was added and the first distillation carried out at the same temperature, the vapour pressure being noted; at th end of this distillation a specimen, about 1 c.c. of the mixture, was with drawn by a pipette, and with the distillate was set aside for analysis; a fres portion of the second fluid was added, and a second distillation made. After the requisite number of distillations the boiler was emptied and dried by a current of air. Several series of experiments could be carried out without taking the apparatus to pieces.

The coefficients of refraction of the distillates and the fluid mixtures were measured and their constitution thence determined by an analytical-graphical method. The coefficients were measured for a series of mixtures of the two liquids; the differences between the molecular-percentage constitution of each mixture, as known, and as deduced from the refraction coefficient by the linear relation, were represented graphically; this curve gave the correction to be applied to the constitution of any mixture of the liquids as calculated by means of the linear relation.

Various sources of error are pointed out and estimates formed of the maximum and average errors thence arising. Tables are given for the sixteen series of mixtures examined showing the coefficients of refraction of various mixtures, the coefficients of refraction and the thence deduced molecular-percentage composition of the fluid and the distillate, the total vapour pressure and the partial vapour pressures of the constituents as calculated from the composition of the distillate.

The relation deduced by Margules between the partial pressure (p_1, p_2) and the molecular fractional composition (x) of the fluid mixture was—

$$\frac{d \log p_1}{d \log x} = \frac{d \log p_2}{d \log (1-x)}.$$

Other methods of verification being uncertain, the author preferred to verify

The integrated form, assuming a general form of functional relation between p_1, p_2 and x, and determining relations between the constants by the above equation. Three ways of determining the constants, and thence the partial pressures, present themselves, viz.: (1) From one of the observed partial pressure curves; (2) from the tangents to the total pressure curves at the points $x=0$, $x=1$; (3) by gradual adaptation to the observed values of the pressures. The results arrived at by these methods are compared. The simplest case is when the constants vanish, which occurs when the concentration ratio in the vapour phase is to that in the fluid phase in a constant ratio equal to the ratio of the vapour pressures of the pure fluids; two examples of this are given and the relation verified within the estimated limits of experimental error. The relation is also verified for seven pairs of mixtures of fluids with normal vapour densities, the results of the experiments and calculations being tabulated and exhibited graphically. For mixtures of fluids with abnormal vapour densities, singled and doubled molecules occurring in the vapour of one fluid, similar relations are theoretically proved, and experimentally verified for mixtures of acetic acid with benzine and toluene, the molecular fractional composition being deduced from the simple, from the double, and from the mean molecular weight. The relation is also tested for mixtures of pyridine and acetic acid and pyridine and water, when feeble chemical combinations occur. The validity of the relation is found unaffected in the first case, but no certain conclusions can be drawn in the second case. W. E. T.

172. *Modern Theory of Solutions.* **E. F. Morris.** (Manchester Lit. & Phil. Soc., Mem. 44. 16. pp. 1–4, 1899–1900.)—The author's views can be best explained by two quotations :—

"An osmotic membrane seems to be only a method for keeping two otherwise completely miscible liquids in contact, in such a manner that their surface-tension effects can be observed."

"The use of the term *dissociation* is most misleading, since it is impossible to separate finite quantities of the ionised bodies without the application of energy." F. G. D.

173. *Heat of Solution and Solubility in the Case of Electrolytes.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 35. pp. 11–17, Oct. 5. 1900.)—In this paper the author gives a short summary of the differences between his formula and that reduced by van't Hoff. His conclusion is that the two formulæ differ only in respect of a term which *in practice* is quite negligible, so that the differences actually observed in various cases do not arise from the formulæ themselves (which are differential formulæ), but are due to errors occurring in the practical application of the *integrated* equations. [See further Abstract No. 1544 (1899).] F. G. D

174. *Solubility of the Alkaline Earth Carbonates in Solutions of Carbonic Acid.* **G. Bodländer.** (Zeitschr. Phys. Chem. 35. pp. 23–32, Oct. 5, 1900.)—From the solubility of carbonic acid in water, the conductivity of the solution, the dissociation of water and the solubility of the carbonate in pure water, the author calculates the solubility of the alkaline earth carbonates in solutions of carbon dioxide corresponding to different pressures of the gas, the results being in good agreement with the experimental values. The concentration of the HCO_3 ions (in gramme-ions per litre) in a solution of calcium carbonate at 16° is given by the expression $0{\cdot}018\sqrt[3]{P}$, where P is the

pressure in atmospheres of the carbon dioxide; for barium carbonate at 16° by $0{\cdot}0158\sqrt[3]{P}$, and for magnesium carbonate at 12° by $0{\cdot}39\sqrt[3]{P}$. The extent of hydrolysis of the carbonates in pure water is calculated in two ways: the percentage hydrolysed being for calcium carbonate 80 or 83·4, and for barium carbonate 78·4 or 84·2. In the case of magnesium carbonate the hydrolysis cannot be accurately calculated, as it goes further than is represented by the equation $CO_3 + H_2O = HCO_3 + OH$, and results in the formation of free carbon dioxide and basic carbonate. Calculations are also given of the hydrolysis of the alkali bicarbonates, which are only stable in presence of a certain proportion of free carbonic acid. For a solution saturated at atmospheric pressure with carbon dioxide and sodium bicarbonate 0·04 per cent. of the latter is decomposed into sodium carbonate and carbon dioxide. If, however, the pressure of the carbon dioxide be equal to that which it has in the air, namely, 0·0004 atmospheres, the proportion of carbonate formed is much greater, and so therefore is the apparent solubility of the bicarbonate, which can only be regarded as having a definite value for a definite pressure of carbon dioxide. T. H. P.

175. *Equilibria between Cuprous and Cupric Ions.* **G. Bodländer.** (Zeitschr. Elektrochem. 7. pp. 159–160, Oct. 4, 1900. Paper read before the 72nd Versammlung deutscher Naturforscher u. Aerzte in Aachen, Sept. 22, 1900.) — The author's first object was to ascertain whether the p.d. between metallic copper and a normal solution of cuprous ions was the same as that between copper and a normal solution of cupric ions. It was found that when air was quite excluded cuprous chloride is partially decomposed as follows: $2CuCl = Cu + CuCl_2$, or $2\overset{+}{Cu} = Cu + \overset{++}{Cu}$ (there was also a slight hydrolysis). A state of equilibrium results, the respective concentrations (for the saturated solution) being, for $\overset{+}{Cu}$, 0·0004 — normal, and for $\overset{++}{Cu}$, 0·0023 — normal. Since these ions are in electrical equilibrium with the copper, and the p.d.'s for solutions containing cupric ions alone are known, the problem can be solved. The calculated values for normal solutions are :—

$$-0{\cdot}43 \text{ volt } (Cu - \overset{+}{Cu})$$
$$-0{\cdot}34 \text{ volt } (Cu - \overset{++}{Cu}),$$

taking the p.d. of the normal hydrogen electrode (normal concentration of hydrogen ions) as zero.

An investigation of the equilibrium between cuprous and cupric ions showed that the ratio C_0^2/C_i was constant. From this it follows that the cuprous ions do not possess the structure $\overset{+}{Cu} - \overset{+}{Cu}$, but are, in fact, monatomic.

For other very interesting applications of the foregoing results to the facts of inorganic chemistry reference must be made to the original paper.

F. G. D.

176. *Pressures of Ammonia in Equilibrium with Metal-Ammonium Solutions.* **W. Gaus.** (Zeitschr. Elektrochem. 7. pp. 158–159, Oct. 4, 1900. Paper read before the 72nd Versammlung deutscher Naturforscher u. Aerzte in Aachen, Sept. 22, 1900.)—The partial pressure of the ammonia was ascertained by passing a measured quantity of electrolytic gas through the solution to be examined and then into standardised hydrochloric acid solution. The exact

oint of saturation was determined by the break in the conductivity curve for ie latter solution. Some salts *increase* the pressure of the ammonia, while thers *lower* it. The former is due to the general effect produced on the olvent medium by the electrolyte ; the latter to the formation of complex netal ammonium kations. The author discusses his results from the point of iew of the Abegg-Bodländer theory of electro-affinity. F. G. D.

177. *Electromotive Activity of the Elementary Gases.* **E. Bose.** (Zeitschr. hys. Chem. 34. pp. 701–760, Sept. 18, 1900. Published in abstract as Habilitationsschrift" of the University of Breslau.)—This is a study of as-batteries with special consideration of Grove's, and the author's con-usions may be thus summed up : (1) The electromotive activity of the lementary gases is conditioned by their solubility in the metals forming the lectrodes. (2) The gases dissolved in the metal are to be considered as issociated either wholly or partially into single atoms by reason of the high issociating power of metals. (3) The ions of an electromotively active sub-ance are to be looked on as formed in the electrode. (4) The electrolytic olution-pressure is measurable by the product of the osmotic pressure of iese pre-formed ions by a factor, constant for each solvent, which may most mply be termed the electrolytic coefficient of distribution. (5) The general neory of gas batteries in which formation of the solvent occurs may be eveloped on this view. (6) The saturation of the electrodes with the gases a process of diffusion in the metal of the electrodes which proceeds with xtraordinary slowness. (7) The Grove gas battery works reversibly, but its m.f. with the gases under atmospheric pressure is in any case higher than ie received value. (8) The acid and alkaline H-O batteries differ in the lace of formation of water, this being at the O-electrode in the acid element id at the H-electrode in the alkaline. (9) The second decomposition-point orresponds to an irreversible process. R. E. B.

178. *Calomel Electrode.* **Rotté.** (Journ. de Physique, 9. pp. 543-545, ct., 1900.)—Employing the capillary electrometer and the Lippmann method, ie author has satisfied himself that the e.m.f. of the normal calomel electrode 0·56 volt. F. G. D.

179. *Action of Light on Lead Peroxide.* **F. Peters.** (Centralblatt f. ccumulatoren u. Elementenk. 1. p. 279, Aug. 15, 1900.)—M. U. Schoop has ated that the lead peroxide layer produced on lead is decomposed by the tion of light. This statement the author doubts, and cites some of his wn experiments. Two lead plates were covered electrochemically with oxide layer, and after thorough washing and being dried in the dark, ie was submitted to the light for 19–23 days, and received 35–40 hours of irect sunlight ; the other was kept in the dark. As Schoop observed, the olour of the one exposed to light became less intense ; but a chemical stimation of the amount of PbO_2 failed to confirm that decomposition had sulted. He concludes that the colour change is due to some physical or olecular effect. W. W. H. G.

180. *Action of Water on Pure Indiarubber.* **H. L. Terry.** (Electrician, 5. pp. 916–917, Oct. 12, 1900.)—Hancock sealed a bag of pure rubber ontaining rather more than 12 oz. of water, and weighed it at intervals ith the following results :—

Date	Oct., 1826.	Oct., 1827.	Oct., 1835.	Nov., 1844.	Oct., 1849.	Feb., 1851.	May, 1854.
Weight	17 oz. 4 dr.	17 oz. 2 dr.	16 oz. 0 dr.	14 oz. 12 dr.	13 oz. 4 dr.	7 oz. 8 dr.	3 oz. 14 dr.

Their loss of weight occurred at atmospheric pressures. Obach gives 24 per cent. as the absorption of water by pure rubber in four months. Increasing the pressure to 8 atmospheres resulted in rubber absorbing in five minutes as much water as it otherwise takes up in two hours. M. O'G.

181. *Metastability of the Cadmium Standard Cell.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 621–631, Sept. 7, 1900. *Cf.* Abstract No. 2065 (1900).)—The fact that cadmium sulphate exists in two modifications was pointed out some years ago, and solubility determinations showed that the transition-point was at 15°, so that below this temperature the sulphate can exist in either the stable or the metastable modification. It is now shown that the cadmium amalgam is metastable below 23°, and is liable to pass spontaneously into a stable modification, causing a rise in e.m.f., of 0·005 volt at 0° C. The cells usually supplied are in the metastable condition, and are therefore of no use as standards of e.m.f. below 23°, since an abrupt increase of e.m.f. may occur at any time, and would not usually be noticed. T. M. L.

182. *Thermodynamics of Standard Cells.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 612–620, Sept. 7, 1900.)—The e.m.f. of the combination—Cd | $CdSO_4$ (dil. sol.) | CdHg (14·3 per cent. Cd)—was found to be 0·05577 volt at 0° and 0·04993 at 25°, whence E = 0·0515 volt at 18°, and $\frac{dE}{dT} = -0{\cdot}000233$. Hence by using Helmholtz's equation the heat required to separate one gramme atom of cadmium from a 14·3 per cent. amalgam is calculated to be 5,436 cal. The solution of this quantity of cadmium at 18° causes the separation from the saturated solution ($CdSO_4 + 15{\cdot}17\ H_2O$) of 1·212 mols. of the salt, $CdSO_4 + \frac{8}{3}H_2O$, so that the thermal changes resulting from the hydration of the cadmium sulphate amount to 7,822 cal. The total thermal change in the element per atom of cadmium dissolved is therefore $-5436 + 7822 + (219900 - 175000)$ cal. $= +47880$ cal., a number which is in satisfactory agreement with the value + 47286 cal., deduced from the e.m.f. of the cell. T. M. L.

183. *Dissociation-Equilibrium in Highly Dissociated Electrolytes.* **H. Jahn.** (Zeitschr. Phys. Chem. 35. pp. 1–10, Oct. 5, 1900.)—The author considers possible objections to his previous work [Zeit. Phys. Chem. 33. 545, 1900; Abstract No. 1888 (1900)]. He shows first that the differential equation of Nernst can be deduced without assuming any laws for the osmotic pressure of the solution, and can be expressed directly in terms of the concentrations.

He also shows how any assumption as to the completeness or incompleteness of the dissociation in the N/600 solutions can be entirely dispensed with, and recalculates his results on this basis. Ostwald's dilution law for highly dissociated electrolytes receives thereby a further very striking confirmation. F. G. D.

184. *Model of Ionic Motions.* **F. Kohlrausch.** (Zeitschr. Phys. Chem. 34. pp. 559–560, Sept. 7, 1900.)—The author describes a model illustrating electrolysis, which is in some respects superior to that devised by Müller [see Abstract No. 1895 (1900)]. It consists of an upright board having a number of parallel channels in which small weights are suspended by threads wound on pulleys of various diameters, which impart to them velocities in proportion to the velocities of the ions they represent. A special pulley is provided for the ions H and OH, whose velocity is exceptional. Two ions having approximately the same velocity may be attached to the same pulley. E. E. F.

185. *Accessory Reactions in Electrolysis.* **A. Brochet.** (Comptes Rendus, 31. pp. 616–618, Oct. 15, 1900.)—When concentrated solutions of sodium hypochlorite are electrolysed, more of this salt is decomposed, and more sodium chlorate is formed, than theory predicts. This result is shown to be due to an *accessory* reaction which is independent of the electrolytic action, although indirectly caused by the latter. The solution in the immediate neighbourhood of the anode is always acid, the consequence of which is that, beside the hypochlorous acid converted electrolytically into chloric acid, a further portion undergoes the same transformation by the purely chemical process of anto-oxidation. N. L.

186. *Electrolytic Reductions.* **W. Löb.** (Zeitschr. Phys. Chem. 34. pp. 641–668, Sept. 18, 1900.)—This paper describes some experiments on the general conditions for electrolytic reduction which were made in connection with researches on the electrolytic preparation of benzidin, to be published elsewhere. Much of the work has been anticipated in a paper by Tafel [see Abstract No. 2287 (1900)], with whom the author is in general agreement. Full details are given of the apparatus employed and of a series of experiments in the electrolysis, using a mercury kathode, of (1) an alkaline solution in the absence of any depolariser; (2) in the presence of nitrobenzol; (3) azobenzene; (4) azoxybenzene; and of acid solutions of (5) azobenzene, and (6) azoxybenzene, these substances being intermediate stages in the reduction of nitrobenzene to benzidin. Stress is laid on the great advantage of mercury kathodes in electrolytic reductions.

The latter part of the paper consists of a reply to Haber's criticisms [Abstracts Nos. 1332 and 1333 (1900)], and the view is maintained that in alkaline solutions the reduction is effected by means of the sodium ions. N. L.

187. *Production of Nitric Acid from Air by the Electric Flame.* **A. McDougall** and **F. Howles.** (Manchester Lit. & Phil. Soc., Mem. 44. 3. pp. 1–19, 1900.)—The authors, after briefly summarising in chronological order the ancient methods for the preparation of this acid, enumerate the present improved methods of production by high-tension electrical discharges.

One of the first attempts appears to have been made in 1859 by Newton, whose apparatus consisted of a number of platinum wire terminals between which electric sparks passed, the terminals being contained in a large chamber, the floor of which was covered with water absorbed the oxides of nitrogen with the subsequent production of nitric acid. W. Crookes in 1892 employed a high-tension alternating current discharge between platinum terminals, depending for its maintenance upon the combustion of atmospheric nitrogen and oxygen. A flame of this nature was utilised by Rayleigh in a research on "The Oxidation of Nitrogen Gas."

A fully detailed description of the electrical arrangements follow, well illustrated with photographs and sketches. Readings of the power consumed in producing the flame are then given, the duration of the experiment being 2 hrs. 30 mins. with a resultant yield of 35 grms. of nitric acid, the average number of watts used in the flame being 172. The combustion chamber utilised in these experiments underwent several modifications before a final form was decided upon. The first consisted of a large glazed earthenware pipe, 76 cm. in length and 20 cm. in diameter, supported horizontally, both ends being closed by slabs of slate.

Air was supplied to the flame by a glass tube at one end, a tube at the

other end conveying the oxides of nitrogen to the condensing apparatus, th gases being drawn through the whole system by means of a powerful pump With this apparatus it was found that an expenditure of 220 watts operatin for 20 hours produced 38·44 grms. of nitric acid per h.p. per 12 hours.

It was next decided to substitute a combustion chamber of form an capacity different from the one already in use, a stoneware bottle, 30 cm. i height and 10 cm. in diameter, being employed. The rate of oxidation in thi apparatus far excéeded that in the previous one. In an experiment extendin over 11 hours 48·76 grms. of nitric acid were produced for a continuou expenditure of 227 watts. This is equivalent to 180 grms. per h.p. per 1 hours, or almost twice the quantity produced in the first apparatus. The vessel finally assumed a form similar to that of a lamp-glass of conica structure, the first experiment conducted in this apparatus extending ove a period of 22½ hours, the power continually used being 225 watts. The pro duction of nitric acid proceeded at the rate of 270 grms. per h.p. per 1 hours, thus showing an increase of 60 grms. over and above the quantitie obtained in the former experiments. It appeared that too great an increas in the air supply diminished the oxidation, and the oxides of nitrogen, being in a state of greater dilution, were more difficult to absorb. On the othe hand, if the air supply was deficient the oxides remained for too long a perio under the influence of the flame, and probably suffered a partial dissociation and a diminished yield of nitric acid therefore resulted. A maximum outpu was obtained by decreasing the high-tension current, so that only 0·1 ampere was used to feed the flame, 55 grms. of nitric acid being produce in an experiment extending over 9½ hours. This is equivalent to 300 grms per h.p. per 12 hours, showing an increase over the quantities produced in all former experiments. A discussion upon the effects of temperature, voltage air supply, &c., is supplemented. O. J. S

188. *Polarisation and Current Density in Solid and Fused Salts.* **A Gockel.** (Zeitschr. Phys. Chem. 34. pp. 529–558, Sept. 7, 1900.)—The complications due to changes of concentration in solutions are avoided by using solid or fused salts, but the very slow depolarisation makes it difficult to work with decreasing current densities, and increasing currents were therefore used. The relationship between current density and polarisation has been investigated in the case of sodium nitrite, sodium nitrate, lead chloride, bromide, and iodide, cadmium iodide, bismuth bromide, and mercuric iodide. The values were calculated from Wiedeburg's formula $p = \frac{Pi}{2 + K}$, where P is the maximum polarisation, p the polarisation at current density i, and K a constant; and also from Planck's formula $p = a + \gamma \log i$, which is based on the assumption that the electrolyte is saturated with the products of electrolysis. In some cases there is a good agreement between the observed and calculated values, but usually there are considerable deviations, showing that complications ensue, due to chemical action of the products of electrolysis on the electrodes, secondary chemical changes in these products, and other causes. T. M. L

189. *Extraction of Zinc.* **L. Belloc.** (Elettricità, Milan, 19. pp. 593–596, Sept. 22, 1900.)—The paper contains descriptions of three patents taken out by Canova and Bertani and one by Casaretti and Bertani, the first for the production of zinc white, and the three others for the production of metallic zinc in the electric furnace.

The last process is worked by the Società Elettro-metallurgica Lombarda

To produce 1 kg. of zinc 2 h.p. hours are required, and the consumption of coal in the furnace is 15 kg. per 100 kg. of ore. G. H. B.

190. *Comparison of Water, Steam, and Gas Power for Electrochemical Purposes.* **O. v. Miller.** (Zeitschr. Elektrochem. 7. pp. 172–186; Discussion, pp. 186–188, Oct. 11, 1900. Report of a paper read before the Deutsche Elektrochemische Gesellschaft at the Zurich Meeting.)—The author opens his very lengthy paper by stating that in recent years German, Swiss, and Austrian electrical engineering firms have equipped water-power stations with an aggregate capacity of 200,000 h.p. for electrochemical industries. In spite of this fact, opinions regarding the ultimate economy of water as a source of power vary, and many authorities still maintain that nearness to markets and to the supplies of raw materials are more important than cheap power. The author in his paper has sought to calculate the ratios between the costs of power when generated by water, steam, and gas. He has limited his inquiry to large installations running continuously, these being the conditions obtaining when power is used for electrochemical purposes.

As regards water the outlay upon a fall 80 metres high, with a discharge of 7½ cubic metres per second, and with natural advantages for development equal to those found at Matrei, is selected for the comparison, and the calculations for steam and gas are based on power-stations of equal capacity—namely, 6,000 h.p.

The water-power station is supposed to contain six 1,200-h.p. turbines, and a supplementary estimate gives the cost of such a station containing five 1,200-h.p. turbines, with two 1,200-h.p. steam engines as reserves. The estimates for the steam-power station are based upon five 1,500-h.p. generating units, and for the gas-power station upon seven 1,000-h.p. units. The figures obtained are summarised in two tables, which are reproduced below.

CAPITAL COSTS FOR 6,000-H.P. INSTALLATIONS (IN MARKS).

	I. Water Power alone. 6 × 1,200 h.p.	II. Water Power with Steam Reserve. 5 × 1,200 + 2 × 1,200 h.p.	III. Steam Power, 5 × 1,500 h.p.	IV. Gas Power. 7 × 1,000 h.p.
I.	Marks.	Marks.	Marks.	Marks.
Capital outlay per h.p.				
a. At the shaft of the primary motor.....	267	347	300	320
b. At the shaft of the secondary motor, 10 km. distant	504	617	550	571
II.				
Capital outlay per kw.				
a. At the switchboard of the central generating station	467	599	517	545
b. At the switchboard of the sub-station, 10 km. distant—				
α) As alternating current supply	603	746	660	688
β) As direct current supply	850	1,022	920	952

RUNNING COSTS PER YEAR (46,000,000 H.P. HOURS) IN PFENNIGE.

	I.	II.			III.			IV.		
		With Coal at pfennige per kg.						With Gas at pfennig per cm.		
		0·2	0·3	0·4	0·5	1·0	1·5	0·10	0·20	0·30
I. *Running Costs per effective h.p. hour.*										
1. At the shaft of the primary motor	0·29	0·61	0·71	0·81	1·11	1·61	2·11	1·00	1·35	1·70
2. At the shaft of the secondary motor, 10 km. distant	0·65	1·08	1·20	1·33	1·70	2·32	2·95	1·55	1·99	2·43
II. *Running Costs per kw. hour.*										
1. At the switchboard of the central generating station	0·59	1·08	1·23	1·37	1·79	2·52	3·25	1·61	2·12	2·63
2. At the switchboard of the substation, 10 km. distant										
(*a*) As alternating current supply...	0·74	1·26	1·42	1·57	2·04	2·83	3·62	1·85	2·41	2·96
(*b*) As direct current supply	1·16	1·79	1·98	2·17	2·72	3·67	4·62	2·48	3·14	3·80

J. B. C. K.

191. *Stirrer with Gas-tight Joint for Electrolysis.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 117–119, Sept. 6, 1900.)—This is a description of a simple and convenient arrangement for electrolytic work when constant stirring of the electrolyte is required. Two forms of apparatus are given consisting in the main of broad cylindrical glass vessels fitted with rubber corks, through which the stirring arrangement passes, the bottom joint being formed by a mercury trap. In the one case the stirrer is fitted with a metallic covering of nickel or copper wire netting which serves as an electrode. The article is accompanied by illustrations. O. J. S.

192. *Commercial Electrolytic Manufacture of Hydrogen and Oxygen.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 18. pp. 441–445, Sept 9, 1900.) —After pointing out the difficulties met with in constructing a suitable commercial apparatus for the manufacture of hydrogen and oxygen, and drawing attention to the necessity of producing pure gases, the author proceeds to enumerate various uses the flame of these gases may be put to, such as lead burning, limelight, and the soldering of cast iron, &c. A list of various places and description of patents is then given dealing with the electrolytic manufacture of hydrogen and oxygen. The author's own apparatus is described as working without a diaphragm, and using dilute sulphuric acid as an electrolyte and lead electrodes. In order to produce 1·5 cubic metres 11 h.p.

ours are required, which is, according to the author, much cheaper than the eneration of hydrogen and oxygen by purely chemical means, such as, for istance, zinc and acid. O. J. S.

193. *Electrolytic Oxidation of Organic Substances by Chromic Acid.* **F. Darmstädter.** (Elektrochem. Zeitschr. 7. pp. 131–133, Sept., 1900.)—In he oxidation of organic substances by chromic acid the latter is reduced to hromium sulphate, from which chromic acid is usually regenerated by gnition with lime. Instead of this chemical process it is more economical o effect the re-oxidation by electrolysis, and this can be done in presence of he substance to be oxidised, the chromic acid being again used as soon as ormed. In this way aniline, when dissolved in the acid chromium sulphate olution, is readily converted by electrolysis into quinone, and ethyl alcohol nto aldehyde. The liquid is well agitated during electrolysis, and there is hus no danger of the accumulation of chromic acid in the solution, and the onsequent destruction of the organic substance by too vigorous oxidation. N. L.

REFERENCES.

194. *Electrolytic Reduction.* **K. Elbs.** (Zeitschr. Elektrochem. 7. pp. 119–120, ept. 6, 1900.)—Reference having been made by Tafel to a method for the continuous udy of electrolytic reductions by the measurement of unused hydrogen evolved at e kathode, devised and briefly described by the author in 1891 (Journ. f. pr. Chemie) portion of the apparatus, differing in detail from that employed by Tafel, is now ore fully described. A diagram is given in the paper. N. L.

195. *Electrochemical Reduction of Aromatic Mononitro-derivatives in Dilute lkaline Solutions.* **K. Elbs.** (Zeitschr. Elektrochem. 7. pp. 133–138, Sept. 20; nd pp. 141–146, Sept. 27, 1900.)—A classified list of substances and their reduction oducts. References are given. The paper is only of chemical interest. N. L.

196. *Universal Eudiometer.* **G. H. Woollatt.** (Chem. News, 82. p. 151, ept. 28, 1900.)—Description of a eudiometer devised to give accurate readings of e temperature, pressure, and volume of a gas through a considerable range these factors. It is especially suitable for demonstration of the laws of Boyle and harles, and is fitted with explosion terminals for use in the analysis or synthesis of ases. T. H. P.

197. *Electrosynthesis of Ketones and Diketones.* **H. Hofer.** (Elektrochem. eitschr. 7. pp. 144–153, Oct., 1900.)—Full details are given in this paper, which chiefly of chemical interest, of the production of diacetyl by the electrolysis of a olution of potassium pyrotartrate, and of the preparation by similar means of etone from a mixture of pyrotartrate and acetate, methylpropylketone from a mix- re of pyrotartrate and butyrate, 2 : 7-octanedione from potassium levulinate, and etonylacetone from a mixture of potassium pyrotartrate and levulinate. N. L.

198. *Goldschmidt Method of Producing High Temperatures.* **E. F. Lange.** ngineering, 70. pp. 450–452, Oct. 5, 1900. A paper read before the Paris Meeting the Iron and Steel Institute.)—The various applications of this process are scribed [see further Abstract No. 1950 (1899)]. J. B. C. K.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

199. *Wigzell's Steam Engine.* (Engineering, 70. pp. 311–314, Sept. 1900.)—This is a vertical triple expansion engine, in each cylinder which there are two pistons moving in opposite directions. Three cran are used, the middle one connected with the three lower pistons by mea of a triangular connecting-rod, and the outer ones each operated by th three upper pistons in a similar manner. This arrangement results in considerable economy of space for the power developed and a reduction vibration to practically nothing; there is also a notable diminution of th pressure between the shaft and the bearings which should increase th mechanical efficiency considerably as compared with the ordinary type. detailed report by W. E. Dalby is given, and includes complete diagrams the crank-effort and an analysis of the balancing of the engine. H. R. G

200. *Test of a Triple-expansion Pumping Engine.* **W. F. M. Goss.** (Mech Eng. 6. pp. 9–13, July 7; and 131–132, July 28, 1900. Abstract of a pap read before the American Society of Mechanical Engineers, May, 1900.)— twelve-hour trial, during which the i.h.p. was 782·9, and the steam con sumption 11·38 lbs. per i.h.p. hour. Steam pressure, 155 lbs. per square inch piston speed, 212 feet per minute. Pump, h.p., 736.3. Drawings, complet indicator diagrams, and data of the trial are given. H. R. G

201. *Smoke Density Indicator.* (Amer. Electn. 12. pp. 426–427, Sept 1900.)—This instrument was exhibited by the Austrian Society of Steam boiler Owners of Vienna at the Paris Exhibition. It consists of a straight tub 1·6 to 2 inches diameter and 40 inches long, closed at both ends by circula discs of glass. A small branch tube at each end permits a sample of the gase from the combustion chamber of the boiler to be continually passed throug the straight tube. An incandescent, electric, or other lamp is placed at on end of the tube, and a funnel with a disc of glass at the other end enables th light to be observed without interference from extraneous illumination. Th smaller end of the funnel, in which the glass disc is fitted, is larger in diamete than the straight tube, and is connected to a tube of this larger diamete placed concentrically outside the other, thus forming an annular space sur rounding the smoke-tube. The light shines without obstruction through thi annular space, whilst in the smoke tube it is more or less obscured, accordin to the density of the gases admitted there from time to time. The ring shaped portion of the glass disc of the funnel corresponding to this annula space is divided into six sectors, one of which is left clear whilst the othe five are shaded, each with a different shade of grey, according to Ringe mann's scale of the degrees of intensity of smoke; so that on looking throug the apparatus the density of the smoke in the central tube may be at onc compared with the shade of one of the sectors surrounding it. It is expecte that this instrument will enable the fireman or stoker to regulate the admissio of air according to the varying stages of combustion, and thus to prevent los of heat.

The following table is given to show the loss caused by excess of air. A admission of 1·3 times the theoretical quantity required for complete com

stion is taken as normal, the loss of combustible being considered as nil this ratio.

tio of admitted air to theoretical quantity	1·3	1·5	1·9	2·4	3·2
rplus beyond 1·3 times the theoretical	0%	15%	46%	85%	146%
ss of heat in flue gases	12 „	14 „	18 „	23 „	30 „
ss of combustible	0 „	2 „	6 „	11 „	18 „
oportion of carbon dioxide in flue gases	15 „	13 „	10 „	8 „	6 „

F. J. R.

202. *Purification of Feed-water.* **J. A. F. Aspinall.** (Railroad Gazette, pp. 569–570, Aug. 24, 1900. Abstracted from "Report on the Question of e Purification of Feed-water of Locomotives and the use of Disincrustants ubject XV. for Discussion at the Sixth Session of the International Railway ngress)".)—The following questions were sent out by the general manager of e Lancashire and Yorkshire Railway to ascertain the practice of the different lways of the world :—(1) What process have you for softening or purifying ter? (2) Give particulars of the process, materials used, &c. (3) What is the st of softening per 1,000 English gallons? (4) Give an analysis of the water fore and after treating. (5) What is the nature of the scale produced m your unsoftened waters? (6) If possible, give an analysis of the scale d the water producing it. (7) Do you insert any material into your boilers · the prevention of scale? If so, of what does it consist? (8) Are you oubled with pitting of boilers or tubes? (9) To what do you attribute the ting action? (10) In what part of the boiler does the pitting occur, and at is its condition as regards scale? (11) In what part of the boiler does e feed-pipe deliver? Do you notice any increase of pitting at this point? ?) What metals are used in the construction of (*a*) Boiler barrel, (*b*) Firebox, Tubes? (13) What lubricant is in use for cylinder lubrication? (14) ave you used zinc blocks or plates for the prevention of scale? (15) How e these attached to the boiler, and what results did you obtain? (16) What your method of washing out boilers? Is cold or hot water used? (17) If t water is used what is its temperature and in what way is it heated?

Table I. gives a summary of those replies to the first four questions in hich the cost is stated.

TABLE I.

Countries.	Number of Roads Replying.	Number of Roads using Purifiers.	Average cost per 1,000 English gallons (Cents).
gentine	2	1	12·0
stria-Hungary	6	5	7·0
lgium	3	1	1·6
ance	8	6	4·7
eat Britain	22	7	2·0
ly	3	1	1·3
rway	1	0	...
therlands	3	1	1·1
ssia	4	1	27·2
ain	1	1	5·0
ited States	5	1	3·3

TABLE II.

Analyses of Water Before and After Treatment.

	Argentine.		Hungarian State.		French State.		Eastern of France.		London & N.-Western.		Midland.		Netherlands State.		Vladikavkaz I.		Vladikavkaz II.		Southern Pacific.	
	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.
Calcium Carbonate	10·78	2·52	14·35	6·23	10·15	3·50	21·21	6·02	17·3	1·4	8·46	2·47	18·76	5·74	9·0	Nil.	...	...	17·15	0·80
,, Sulphate.....	2·03	Nil.	11·76	...	5·25	0·98	10·51	. .	1·1	1·0	3·65	Nil.	8·82	7·84	19·41	7·63	39·19	6·02	6·08	0·35
,, Nitrate	2·87	Nil.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Magnesium Carbonate ...	7·35	5·74	12·11	11·41	5·74	1·05	9·38	7·91	0·8	0·6	1·05	0·21	...	...	6·17	Traces.	22·34	Nil.	1·46	7·15
,, Sulphate	...	...	...	...	2·17	0·84	...	...	...	...	2·89	1·74	11·34	11·34	...	...	25·15	24·94	20·58	1·95
Sodium Carbonate	Nil.	7·07	...	...	...	...	...	...	...	...	...	...	...	...	...	10·44	...	34·13	...	...
Silica, &c.	2·52	3·08	0·91	0·77	...	...	...	...	0·3	0·1	...	...	...	...	...	...	...	...	1·81	0·33
Alkaline Salts.....	...	...	...	...	...	...	...	18·97	...	...	...	...	...	...	...	...	...	...	14·77	40·35
Total scale-forming matter	21·0	9·5	54·46	47·60	...	...	47·88	37·8	19·5	3·1	13·16	2·68	...	...	...	...	...	...	47·08	10·58
Total dissolved solids at 212° F.....	...	...	...	...	...	...	...	...	23·0	6·5	22·30	14·30	...	...	...	...	...	...	...	...
Total solids dried	...	...	...	...	...	...	...	...	...	...	...	...	...	...	70·84	50·40	217·56	221·06	61·85	50·93
Total hardness	25°	9·8°	37·2°	19·7°	31°	8°	46·2°	15·4°	21·2°	3·6°	14·7°	4·2°	34·7°	...	30·6°	5·6°	74·2°	24·5°	40·41°	11·25°
Permanent hardness	...	...	13·6°	...	29°	8°	21·7°	8·4°	3·6°	1·6°	...	...	21°	...	14·3°	5·6°	47·6°	24·5°	21·51	9·38°

The above results are expressed in grains per gallon. The degrees of hardness are English degrees.

Processes used.—The *Buenos Ayres Great Southern Railway* (Argentine epublic) use the Tyacke apparatus, softening 2,000 gallons per hour by the ldition of a fixed quantity of quicklime and caustic soda to the water per our.

The *Hungarian State Railway* uses the Beranger-Stingl and also the ollacsek apparatus, the reagents being soda and lime.

The *French State Railroads* use three systems—(1) An intermittent system, quantity of water being mixed with lime and carbonate of soda, and filtered ter settling for twelve hours. (2) Beranger-Stingl purifier. (3) Gaillet rifier.

The *Eastern of France.* Up to 35 degrees of hardness soda is used, above at milk of lime is added separately to precipitate bicarbonate of lime.

The *London and North-Western* uses Clark's process, with modifications by orter and Howatson, lime alone or with sodium carbonate being added, with bsequent filtration or subsidence.

Midland Railway (England) uses the Archbutt-Deeley process, employing reagents lime and sodium carbonate.

Netherlands State Railroads. A solution of soda is added to the feed-water the proportion of 35·27 lbs. per 22,000 gallons of water.

Vladikavkaz Railroad (Russia). The Beranger-Stingl apparatus or a odification is used, with caustic soda solution as the reagent. The alyses I. in Table II. show the results on water containing small quanies of magnesium salts, and analyses II. show the effects on water containing rge quantities.

Southern Pacific Railway uses a process based on the chemical principles the Porter-Clark process, concentrated solutions of the reagents being jected into the main feed supply.

The analyses of the water used on these railways before and after treatent are given in Table II.

The Southern Railway of Austria uses the Beranger-Stingl apparatus, with ilk of lime and soda, the analysis of the water before and after treatment ing given as follows :—

Lime	Before treatment		13·72	After	1·4
Magnesia	„	„	8·61	„	3·7
Combined Carbonic Acid	„	„	13·02	„	1·0
Total hardness	„	„	44·64°	„	11·7°

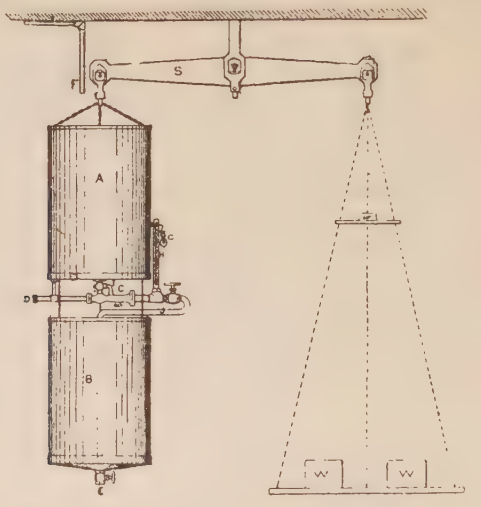
Apart from preliminary treatment of the water, several railways use disinstants in the boilers or tanks of locomotives. Various substances are used. he Report must be consulted for a list of these, and also for the very full plies received on the subject of pitting and its causes.

Twenty-six railways out of 63 use hot water for washing out the boilers, e hot water being of from 120° to 140° F., and 37 use cold water. F. J. R.

203. *Steam Calorimeter.* **J. Goodman.** (Elect. Engin. 26. pp. 337–339, pt. 7, 1900. Paper read before the British Association.)—Recent work ving shown that the specific heat of superheated steam—upon which the re-drawing steam calorimeter depends—is not even approximately con-nt, or in accordance with any ascertained definite law, the author has vised the new form of the condensing calorimeter shown in the figure.

The scale beam S is about 42 inches long, and will turn with 0·01 lb. nen weighing 120 lbs. The tank A is filled with water from the pipe F til the weights in the large scale pan (W_1) are just balanced, tank B being

empty. The temperature of the water in A is accurately measured (t_1), an then the sample of steam to be tested is admitted through the pipe D an mixes in the injector C with the water on its way from A to B. The mixtur passes a thermometer H, which is read every 10 or 15 seconds (t_2), and delivered through the pipe J to the bottom of tank B. When A is near emptied, steam and water are cut off, and the weight of steam taken is foun by placing weights (w) in the small scale pan until the balance is restore Tap E is then opened, and tank B allowed to drain, after which balance



again made by replacing W_1 by W_2 [w being removed]. $W_1 - W_2$ gives th quantity of water mixed with the steam; then—

$$w(xL + t - t_2) = (W_1 - W_2)(t_2 - t_1).$$

The author considers that the fairest way of taking the sample from horizontal main steampipe is by a perforated pipe along a vertical diamete as this catches the film of water which creeps along the bottom of the ma pipe. It is also stated that the accuracy of a steam calorimeter may checked by testing a sample from a vertical steampipe immediately over boiler from which no steam is flowing except that required for the samp as such steam would be perfectly dry. H. R.

204. *Disposal of House Refuse in Bradford.* **J. McTaggart.** (Elect. Re 47. pp. 415–417; Discussion, pp. 417–418, Sept. 14, 1900. Abstract of a pap read before the British Association.)—The population of Bradford is estimat at 292,300; the acreage is 22,843; the average number of people per acre 12 and the rateable value is £1,396,067 7s. 6d. The total quantity of refu collected is 125,000 loads per annum from 32,164 ashpits, to which 180,0 visits are paid, giving an average of 3·87 loads per ashpit and 5·6 visits annum to each.

At the present time about 90,000 loads are destroyed annually at destructors, the remainder being either tipped in the out-districts or sold farmers. The total number of destructor cells is 53, being 29 at wo 6 rebuilding, and 18 to be erected. These when complete will have a to destroying capacity of 145,000 loads per annum.

The destructors are of the Horsfall pattern, each one consisting of two ocks of six cells of the back-to-back type, with two 11 feet by 8 feet multi-bular boilers, the chimney being placed between the two blocks. Each ock of cells has a flue leading to one of the boilers and an alternative flue ding to the chimney. Some improvements in details of construction have en introduced, and air flues have been made under the tipping-floor, which ep it cool by the induced current of air passed through them by means of a am-jet. An overhead railway is also provided for the removal of the clinker. working test of the destructor gave the following results :—

TEST OF THE HORSFALL DESTRUCTOR, JUNE 24 TO JULY 7, 1900.

Number of cells : 12.
Type : Back to back.
Duration of test : 278 hours.
Nature of fuel : Midden, market and dry refuse.
Number of men employed : 12 furnace men, 6 chargers.
Wages : Furnace men, 28s. ; chargers, 25s.
Total quantity of refuse burned : 2,896,320 lbs. = 1,293 tons.
„ „ „ per cell per 24 hours : 20,837 lbs. = 9·3 tons.
Total cubic feet of refuse burned per cell per 24 hours : 543.
Total quantity of refuse burned per square foot of grate per hour : 34 lbs.
„ „ „ per cell per hour : 868 lbs.
Cost of labour per ton destroyed : 9d.
Total weight of water evaporated : 2,153,000 lbs.
„ „ „ per hour : 7,744 lbs.
„ „ „ per cell per hour : 645 lbs.
Water evaporated per lb. of refuse burned : 0·743 lbs.
„ „ „ „ from and at 212° F. : 0·882 lbs.
Weight of clinker produced : 817,516 lbs. = 364·96 tons.
„ fine ash „ 26,936 „ = 12·02 „
„ fine dust „ 5,992 „ = 2·67 „
Total weight of residuals : 850,444 lbs = 379·65 tons.
Percentage of residuals : 29·36 per cent.
Steam pressure maintained (by recorder) : 60 lbs.
Temperature of feed-water : 60° F.
„ gases in main flue : 1,800° F.
„ „ at bottom of chimney : 1,000° F.
Average air pressure (water gauge) : $\frac{7}{8}$ inch.
Total I.H.P. per hour at 20 lbs. : 387·2.
„ per cell continuously : 32·2.
I.H.P. hours per ton burned : 83·2.

The main importance of the installation lies in the arrangements for ning the residuals to profitable account. The steam produced is partly ised in driving eight mortar mills, which turn out mortar at the rate of 000 tons per annum, and for working hydraulic machines, which are used the production of artificial stone slabs for paving. Concrete bricks, sisting of a 10 per cent. mixture of hydraulic lime and clinker, are also nufactured at a cost of 14s. per 1,000. A small machine turning out 8,000 cks per day requires over 20 tons of clinker for that purpose ; and the nufacture of ornamental tiles from the same material is being commenced. ed clinker of various grades is also disposed of by sale, and old tins, scrap n, &c., go to chemical works, scrap merchants, and others. In addition to

the machinery above mentioned there is a complete plant for the manufactur of artificial guano from the fish refuse, of which from 600 to 700 tons are dea with annually and reduced to 25 per cent. of its original bulk, making a profi able product which is sold at £3 per ton.

The new destructor being erected will reduce the labour for tipping an charging, and is expected to reduce the labour cost of destroying the refus to 5½d. per ton.

The following statement shows how the power generated during th fortnight's trial recorded above was utilised, and the returns from it :—

	£	s.	d.
306 tons 13 cwts. 2 qrs. of mortar made and sold, value ...	82	8	6
442 tons of crushed clinker sold, value.....	14	14	8
245 sq. yds. of concrete flags manufactured, value.....	38	15	10
3 tons 3 cwts. 3 qrs. old tins sold, value	0	15	11
About 4 tons of fish guano manufactured, value	12	0	0
	£148	14	11

Discussion.—**C. E. Webber** alluded to the project of combining destruct works at Kensington with plant for generating electricity for distribution, upo which he had reported some years ago. He found that the calorific value London refuse was too low to permit of such a project being worked econom cally, but **G. Watson** pointed out that the development of electric tramway now introduces a profitable day load for electric installations. **J. McTaggar** however, in reply, considered it the better plan always to have comple electric plant apart from destructors, since the calorific value of the refu varies greatly from day to day, and the steam power can be profitably utilise in the other directions indicated. F. J. I

GAS AND OIL ENGINES.

205. *Efficiency of Port Valves of Internal Heat Engines.* **H. D. Meie** (Horseless Age, 6. pp. 13–15, Sept. 19, 1900.)—The author deals with exper ments on a small internal-heat engine, arranged so that it could be driven any speed between 100 and 350 r.p.m. from an external source of power. A indicator having a spring graduated at 15 mm. to 1 atmosphere was connecte to the engine cylinder, and cards taken. These show that during the suctio stroke, with either the admission valve held full open and exhaust valv operating, or *vice versâ*, a vacuum is formed, and considerable back pressu exists on the exhaust stroke. Diagrams showing these features were obtaine even when both valves were held full open. The author points out that th is the only satisfactory way of arriving at a knowledge of the sufficiency otherwise of the ports and valves in high-speed engines, and calls attentio to the fact that certain indicator cards of a 125-h.p. gas engine taken b C. H. Robertson [Abstract No. 898 (1900)] show back pressure and parti vacuum even with 100 and 160-lb. springs. C. R. D'

206. *Compressed Air Motors.* **H. D. Cooke.** (Street Rly. Journ. 16. p 879–880, Oct., 1900. Paper read before the New York State Street Railw Association, Sept., 1900.)—After stating that nothing has yet been acco plished in the manufacture of liquid air which will warrant its considerati for operating street railways, the author deals with the latest compressed-a cars now in use in three cities in the United States. Those now employed

e Metropolitan Street Railway Co. of New York are fitted with two engines, ch directly connected to one pair of wheels. The one pair of wheels is nnected to the other pair by connecting rods. The air passes from storage bes to the engines through a reheating water tank, the initial temperature which is 300°. This reheating is shown by experiment to nearly double e mileage of the car; with cold air a 35-cubic-feet storage ran a car eight iles, and the same car ran fifteen miles, using the reheater. A controller of mple form varies the cut-off from one-tenth to five-eighths of the stroke, and ves all other necessary regulations. An air-brake and a special starter are ted to the cars, both of these being controlled by a single lever. Other cars ve now been used in Chicago for sixteen months on night duty; they metimes haul two trail cars, and have proved successful in all weathers. he storage tubes are of mild steel, tested to 5,000 lbs. per square inch; they ork at an initial pressure of 2,000 lbs., and are charged from a stationary ttery of similar tubes. The tubes in the power-house are charged to a essure of 2,500 lbs., and they recharge the car tubes in about two minutes. he air passes through a reducing valve before entering the reheater, and pressure is then 150 lbs. per square inch. The exhaust from the engine ver falls below 70°. When compressing the air originally its temperature reduced to that of the atmosphere by a water-jacket system; all moisture removed by a separator, through which it passes on its way to the storage ttery. The Chicago cars consumed, during six months' working, an erage of 409 cubic feet of free air per car mile; the weight of the car is t given. It is estimated that the cost of compressing 1,000 cubic feet of e air to 2,000 lbs. per square inch is 2·8 cents; in this figure coal is taken \$2.90 per ton, 2 lbs. of coal per i.h.p. per hour; labour, sundries, and per cent. depreciation are included. A. G. N.

207. *Collin-Dufresne Ignition Apparatus.* (Locomotion Automobile, 7. pp. 7–598, Sept. 13, 1900.)—This article describes a form of ignition tube for plosion engines, which depends on the fact that spongy platinum once ndered incandescent will continue so if immersed in hydrocarbon vapour. he platinum ignition tube D is of the kind ordinarily used for petroleum

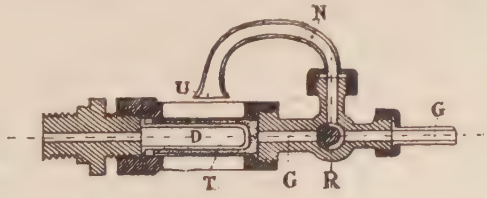


Fig. 1.

irit engines. It is surrounded by a second tube T, and the space between filled with spongy platinum. Air, carburetted by bubbling through petrol, sses under pressure along the tube G. When the cock R is in the position own, the mixture passes along the tube N, and being ignited at U raises e tube T, and the spongy platinum to a bright red heat. The cock R is en turned so that the hydrocarbon vapour proceeds along G, coming into ntact with the spongy platinum, which continues to glow, although the me at U has been extinguished. The inner tube D is thus heated to incan- scence for a length which depends on the pressure of gas in G. The point firing the charge may thus be varied by adjusting the cock R. Two other

illustrations are given, showing the method of generating the carburetted air, and the application of the complete apparatus to a petrol engine.
C. R. D'E

208. *Bournonville Acetylene Generator.* (Eng. News, 44. pp. 234–235, Oct 4, 1900.)—A gas generator of the type in which the carbide is automatically fed into the water. A toothed drum conveys the carbide from a closed hopper into a vessel holding water. The feeding drum is caused to revolve when a gas-holder, forming part of the apparatus, begins to fall. The mechanism employed for this purpose consists of a system of levers connecting the floating holder with a pawl, which actuates a toothed wheel on the drum spindle. The carbide drops from the drum through the water inside a chamber provided with deflector plates, which prevent the gas from rising inside this chamber. A pipe leads from the top of the generating vessel through a small trap, to a condensing chamber, and from there the gas passes through a filter to the floating gas-holder. Blow-off pipes are provided for the carbide chamber, the condensing chamber, and the gas-holder. The bottom of the generating vessel is fitted with a scraper which can be revolved by hand; a discharge valve and flushing-pipes are also provided for thoroughly cleaning out this vessel. A sectional drawing, showing the arrangement of the various parts, accompanies the original description.
A. G. N

AUTOMOBILISM.[1]

209. *Marsh Motor Cycle.* **A. R. Marsh.** (Scientific American, 83 pp. 100–101, Aug. 18, 1900.)—Describes a compact form of motor bicycle in which a small petrol motor is attached to the seat-post tube of an ordinary diamond frame, and drives the rear road wheel by means of a single reduction chain gear. The motor in general design closely resembles the air-cooled motors of de Dion and Bouton. It has a single vertical cylinder bolted to a crank case, in which the flywheel crank revolves, oiled, and protected from dust. The motor is stated to weigh only 20 lbs., it is 14 in. high × 4 in. wide overall, the cylinder is $1\frac{7}{8}$ in. diameter × $2\frac{1}{4}$ in. stroke, and drives the bicycle at 30 miles per hour. It is fixed between the upper and lower stay tubes, and in front of the seat-post tube, this being employed to lead the exhaust gases to the silencer. The petrol tank and the carburettor are attached behind and below the saddle; one quart of petrol is stated to suffice for 100 miles. The ignition of the explosive mixture in the motor cylinder is effected electrically, an induction coil and a dry battery of very small dimensions and weight being attached to the top stay tube. The several control levers are also attached to this tube. A free-wheel chain driver is employed to start the bicycle. The total weight is 60 lbs.
C.R.D'E.

210. *Working Costs of Automobiles for Street Watering and Dust Removal.* **E. Shrapnell Smith.** (Automotor Journal, 4. pp. 628–629, Sept., 1900. Excerpt from a paper read before the Association of Cleansing Superintendents of Great Britain, Aug. 30, 1900.)—This paper contains analyses of the results obtained with steam motor vehicles for cleansing purposes. From figures supplied by A. Ramsden, surveyor, of Chiswick, the horse contractor's tender for the year ending March 31, 1898, was £1,900, whereas the actual cost o

[1] Electric Automobiles are described in the section dealing with Electric Traction.

oing the work of dust removal in this district with two steam tip-vans was £1,253. From this it is calculated that £1,228 would be saved in three years by the use of steam vehicles, notwithstanding a mean annual increase of 185 ouses in the district. J. A. Brodie, city engineer, Liverpool, states that the orking of a 4-ton Leyland steam van has proved "satisfactory and highly conomical." A similar opinion is stated to be given by T. W. E. Higgens, urveyor to the Chelsea Vestry. The Strand Board of Works has employed Thornycroft vehicle for dust removal and watering for about six months, ith the result that their engineer, A. Ventris, states that this vehicle does the ork of three single-horse dust-carts "better and more speedily"; also "it as displaced two water-vans, horses, and drivers. Based on these results the llowing figures are given, in which the first set give the cost of the carts, c., discarded, and the second set the cost of working the steam car by hich they were displaced :—

	£	s.	d.
Hire of five horses and harness (feeding and stabling done by contractors), at £65 per horse	325	0	0
Hire of two water-vans, at £16	32	0	0
Three drivers of dust-vans, at £71 10s.	214	10	0
Two drivers of water-vans, at £84 10s.	169	0	0
Oiling and repairing three dust-vans, at £8...	24	0	0
Third-party insurance on five vans	7	10	0
Total reduction in cost per annum	£772	0	0

Dust-vans are owned by Board, and used for other purposes.

The expenditure in respect of the motor has been :—

First Period.—Hire for eight weeks at £7 10s. per week, for day work only, nclusive of all charges.

Second and Third Periods.—These aggregate a clear three months. The ppended table, supplied by Mr. Ventris, is in proportion, and may be relied pon as being the outcome of experience.

Estimated Annual Expenditure.

	£	s.	d.
Interest and return of capital, spread over 10 years, say...	82	6	0
Fuel—36 cwts. per week, at 32s. per ton	150	0	0
Wages—Two drivers at 37s. per week	192	8	0
Attendant to work levers of water-van on day shift, at 25s.	65	0	0
Repairs—Thornycroft's guarantee	75	0	0
Lubrication and waste	20	0	0
Boiler insurance on £2,000	3	4	0
Third-party insurance	10	10	0
Total cost per annum	£598	8	0

These figures show a saving of £173 12s. per motor car per annum.

C. R. D'E.

211. *Cowles' Variable Speed Gear.* (Automotor Journal, 4. p. 603, Sept., 900. Drawings from the Motor Age.)—This article describes a gear in hich variations of speed are obtained by varying the radius of action

of a pair of friction wheels pressing on either side of a disc. In a motor vehicle the motor drives the friction wheels in opposite directions by means of jointed rods, and the driven disc is mounted on the exterior of a differential gear on a countershaft which drives by single reduction spur gears the independent axles of the road wheels. C. R. D'E.

212. *Capel's Motor Car.* (Automotor Journal, 4. pp. 551–556, Aug., 1900.)—This article describes and illustrates a light petrol car to carry three persons designed especially with a view to secure accessibility and simplicity of mechanism and control arrangements. There is no underframe proper but several essential parts of the mechanism are built together and suitably sprung from the axles so as to form the support for the carriage body, engine and driving gear.

The engine, which develops 4 b.h.p. at 800 r.p.m. has two horizontal cylinders, each 3-inch bore by 5-inch stroke. It is placed at the back of the vehicle below the principal seats and drives the live rear axle through a combination of leather-covered chain and helical spur gear, giving forward speeds of 4·5, 12, and 20 miles per hour, and one reverse speed. A modified form of Ackerman steering gear is employed which is claimed to be very sensitive and so arranged that the shocks imparted to the wheels cannot act back on the steering lever. The cooling water for the cylinder jackets is circulated by means of a rotary pump and is cooled by passing through a Clarkson radiator placed in the front of the car. Shoe brakes are employed, which act on the tyres of the rear road wheels. C. R. D'E.

REFERENCES.

213. *Stéate Electric Ignition Plug.* (Automotor Journal, 5. p. 31, Oct., 1900.)—This article describes and illustrates a well-designed form of sparking plug for explosion engines invented by Frémy and Mare. The insulating material of the plug is steatite or soap stone, which has a high insulating value, and appears less liable to breakage than the porcelain insulators usually employed in these plugs. C. R. D'E.

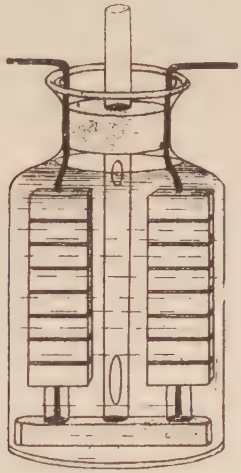
214. *Heavy Automobiles.* **F. W. Maynard.** (Eng. Mag. 19. pp. 825–840, Sept., 1900.)—Descriptions and photographic illustrations of vehicles referred to in Abstracts Nos. 899, 902, 904, and 905 (1900). C. R. D'E.

215, *Automobiles at the Paris Exhibition.* (Automotor Journal, 5. pp. 1–21, Oct., 1900.)

216. "*Thousand Miles*" *Automobile Trial.* **W. W. Beaumont.** (Eng. Mag. 20. pp. 81–98, Oct., 1900.)—The author gives an account of all the principal vehicles competing in the trial, together with practical considerations on the general results. The mechanical efficiencies of the principal cars, as deduced from the hill-climbing and speed trials, are given, and the article is illustrated by numerous photographs. [see further Abstract No. 2481 (1900).] C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

217. *Storage Cells for High-tension Batteries.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 18. pp. 478–479, Sept. 30, 1900.)—Batteries consisting of a large number of small storage cells are coming more and more in use for cable testing, the standardisation of high-voltage instruments and other purposes. The form shown half full-size in the figure is manufactured by the Cölner Accumulatoren-Werke, G. Hagen, at Kalk, near Cologne. The containing vessel is a wide-mouthed bottle of white glass provided with a rubber stopper. The framework of the electrodes is made in the usual manner, pasted and then formed. The capacity is such that a discharge at the rate of $\frac{3}{4}$ ampere will cause in an hour a fall of 10 per cent. of the voltage. At the bottom the



electrodes are fixed to a glass bridge, and between them is a glass tube with two side-holes for gases to escape and for allowing the addition of distilled water to be easily made, the air passing out of the upper opening. The cells are mounted in sets of 25 in paraffined wooden trays. A photograph of the battery of 2,200 such cells, made for Felten and Guilleaume, of Mülheim, and used for cable-testing at 4,000 volts, is reproduced. The cells are charged by placing the groups in parallel and using a 70-volt dynamo. On short circuit each cell gives 11 amperes with a potential difference of one volt. The 2,200 cells on short circuit would thus correspond with 32 e.h.p. W. W. H. G.

218. *Wehrlin Accumulators.* **H. Wehrlin.** (Zeitschr. Elektrotechn., Wien, 18. pp. 395–397, Aug. 12, 1900.)—The general requirements of a battery suitable for rapid discharge and charge are discussed, and the plates manufactured on the Wehrlin system by the Accumulatoren-Fabrik Wüste and Rupprecht of Baden and Vienna are described. The positive plates have a total available surface of 9–9·5 times the apparent surface and are made of horizontal parallel lamina specially arranged ; the negative plates are of the grid type, having pastilles very firmly held. Curves are given confirmatory of the successful design of these plates for buffer battery use. A comparison is also

made of their capacity with others, and the following figures are taken fro the curves, where the capacity of each type is compared with its value for three-hours' discharge :—

Type.	Capacity, Ampere-hours. Time of Discharge in Hours. 3	2·5	2	1·5	1
"Fr." Wüste and Rupprecht.....	100	96	91·5	83	74
"G.S." Acc. Fabrik Actien-Ges...	100	93	86	79	72
"Ru Rg." Acc. Wrk. Pollak.....	100	93·5	86·5	77·5	68
"R.K." „ „ „	100	91	81	73	64

W. W. H. G

219. *Formation of Accumulator Plates.* **G. Carro Cao.** (Elettricit Milan, 19. pp. 707–709, Nov. 10, 1900.)—This paper describes experimen undertaken to determine the variation of capacity and resistance of paste plates during the period of their formation. The lead plates were immerse in dilute nitric acid, then washed, and made up in their cells with 10 per cen acid ; after undergoing several charges and discharges they were pasted, an 46 charges and discharges made, the discharge being carried on until th e.m.f. had diminished 10 per cent. below its initial discharge value. Bot the capacity and resistance were found to increase regularly during th formation of the plates, but became constant after the fortieth charge an discharge. G. H. B

220. *Accumulator Charging at Constant Potential.* **C. Heim.** (Elektro techn. Zeitschr. 21. pp. 269–272, April 5 ; 288–290, April 12 ; 309–312, April 19 329–331, April 26 ; 347–349, May 3 ; 391–394, May 17 ; 416–419, May 24 438–441, May 31 ; 463–465, June 7 ; 487–491, June 14, and pp. 504–507 June 21, 1900.)—A long series of experiments made by the author to compar the effects of charging at constant potential and with constant current on th capacity and efficiency of accumulators gave the following results. Thi energy efficiency of cells charged at a constant potential of from 2·4 to 2· volts is only about 3 per cent. less than that when charged with constan currents, the time of charge with constant current being 3½–4 hours ; th same charge is given at a constant potential of 2·5 volts in 1½ hours ; two thirds of the charge is given in ½ hour, and in the latter case the efficiency i about 4 per cent. greater than in the case of the complete charge. In these comparisons the discharge current was kept constant at a value slightly greate than the constant charge current. When discharged at twice this rate th efficiency fell about 3 per cent. In a series of charges and discharges withou intermediate pauses, the mean charging current and the capacity increase (i a series of five charges and discharges the increase of capacity was abou 15 per cent.). This was found to be due to the increase in the temperatur of the cell (amounting in the case mentioned to 12·5° C.), which, according t the author's explanation, diminishes the viscosity of the acid, and thus pro motes the diffusion of the acid formed in the pores of the active material Charging at constant potential causes the fall of more active material tha does charging with constant current, owing to the high current density at th commencement of the charge, but the effect diminishes with successiv charges. After a series of 70 charges and discharges a loss of capacity o 5 to 6 per cent. was noted. G. H. B

221. *Maximum Demand Indicator.* **J. H. Barker.** (Elect. Rev. 47 pp. 418–419 ; Discussion, p. 419, Sept. 14, 1900. Paper read before the Britis

ssociation.)—This instrument is a maximum demand indicator combined ith an integrating wattmeter of the motor type employing a magnetic brake evice such as the Thomson-Houston meter. The magnetic brake consists of copper disc revolving in a horizontal plane between the poles of two permanent magnets. The two magnets instead of being permanently fixed are upported on a beam and suspended in such a manner that they tend to follow ne rotation of the disc. The suspension is a steel wire enclosed in a tube and xed at its lower end to the beam and at its upper end to a screw. The orsion of the steel wire acts as a spring and controls the distance through hich the suspended system moves. The spring or other controlling force made comparatively strong in order that the motion of the magnet poles ay be so small as not to effect the rate of the meter, and also in order that ne period of oscillation of the suspended system may be short.

When there is a sudden increase in the current the magnetic brake would nd to swing beyond the position proper to the new current if the period of scillation were not short in relation to the time taken by the revolving parts attain their new velocity. The motion of the brake is multiplied and ctuates an indicator. A light ratchet and pawl is fixed at one end of the eam and retains the device at its point of maximum deflection ; a lever with sealing device passes through the outside of the case and enables the meter nspector to re-set the indicator. E. C. R.

222. *Service Joint-box.* **L. Andrews.** (Lightning, 18. pp. 361–362, Oct. 1, 1900.)—The author describes, with illustrations, a joint-box for triple oncentric mains invented by J. Glass, which is in use at Hastings. The box osts £1, and a joint can be made with it in a little over half an hour. To oid frequent cutting of the outer conductors of the cable small installations e coupled to the neutral and outer, only the large ones being connected with e neutral and inner. The box is very compact, and little skill is necessary in s use. A. H. A.

223. *Cable-Making.* **W. Maver.** (Cassier, 18. pp. 467–479, Oct., 1900, nd Electrician, 45. pp. 967–969, Oct. 19, 1900.)—Aluminium wire has 1·27 nes the diameter of copper of the same conductivity, and hence is little used covered cables. Red-hot copper ingots of 200 lbs. weight are rolled into ds by passing backwards and forwards through a mill by men at each side. hen small enough the rod is passed on from the smaller mills by curved ides and rolled down to No. 7 B.W.G. Before drawing, the wire is covered ith flour paste as lubricant. The shell hardness produced by drawing is reoved by annealing. Tinning is effected by passing it through a vat of molten n. In the U.S.A. wires are not stranded unless larger than 0·257 inch diameter o. 2 B & S gauge). Machines carrying up to 130 reels, each weighing 00 lbs., are used for stranding. Crude rubber is bought in balls weighing om 5 to 60 lbs. Washing, by passing the material through a mill soused ith water, reduces the weight 20 per cent. This washing is effected after elve hours' soaking at 200 to 212° F. The material leaves the washer as a gged sheet, which is dried in air for three weeks. A well-known cable ixing contains :—

Para	15 lbs.
Litharge	4·5 ,,
Whiting	6 ,,
Blue lead	4·5 ,,
Sulphur	7 oz.

Very low-grade rubber may be applied seamlessly through the screw feed pipe machine and allowed to rest in a bed of talc. It is then coiled on drum, taped if necessary, and vulcanised in a steam chamber at 250 to 300° F according to the grade of rubber. The ordinary and better horizontal machine, which applies rubber strip by passing it and the cable through grooved steel rollers, is described. For fibre cables paper is loosely coiled o a wire, the whole is baked till dry, and then immersed in insulating oil. Th several conductors of a cable are then stranded together, jacketed with wir insulation, and lead-covered; a small increase beyond 2 per cent. of tin i the lead will double the pressure necessary in the lead press. The highes voltage used in New York on covered cable is 6,600 volts on a 10-mil circuit; the maximum energy in a single circuit transmitted is 2,700 h.p. Th thickness of rubber insulation on this cable (0·5-inch diameter) is $\frac{5}{32}$ inch o each member, and a jacket of $\frac{5}{32}$ inch outside the three members. Eac member, and also the jackets, are severally taped. Three miles of 25,000 volt underground cables are soon to be operated. The three wires of th cable are No. 2 B & S gauge; the insulation is $\frac{7}{32}$ inch diameter on each with a jacket of $\frac{5}{32}$ inch. The maximum advantageous pressure for overhea lines is thought to be 40,000 volts. M. O'C

224. *Cable Faults.* **J. Wright.** (Elect. Rev. 47. pp. 605–607, Oct. 1 1900.)—Chips of wood from the centres of the rubber rolls escape observatio in vulcanised rubber cables, as also cotton threads or jute, but in the case o gutta-percha they are detected by visual inspection. If the wire is not taut i running through the "longitudinal" machine the rolls will sometimes crus off a splinter of copper, which pierces the insulation. The same occurs whe a kink passes. Bad longitudinal seams are due to faulty rolls which have no been reground after extensive use. A double lap of pure rubber is recom mended. Flattening of the unvulcanised paste by over-tight drumming an taping, broken wires inside an unbroken rubber cover, birdcaging of hard drawn strands, and lead oxide faults in the lead sheath are remarked on. M. O'C

225. *Heating of Electric Cables.* **J. Herzog** and **C. Feldmann** (Elektrotechn. Zeitschr. 21. pp. 783–788, Sept. 20, 1900.)—The heating o electric cables is here treated both experimentally and theoretically. Th experiments were made on single-core cables and three-core concentric cable the single-core cables having sections of 10 and 100 sq. mm. and the thre cores of the concentric cables having sections of 10, 100, and 200 sq. mm per core in the three concentric cables used. Experiments were als made with a three-core non-concentric cable, each core having a section o 150 sq. mm., this cable in one series of experiments being buried in sand at depth of 73 cm. and heated by three-phase currents. The experimenta results are given in tabular form and in curves in the paper.

The latter part of the paper deals theoretically with the problems of th conduction of heat in cables of different forms and in the earth surroundin a buried cable. [See Abstracts Nos. 1924 and 1925 (1900.)] J. B. H

226. *Ougrimoff Electric Calorifactor.* **J. A. Montpellier.** (Électricie 22. pp. 177–179, Sept. 22, 1900.)—The Ougrimoff electric heater (or *calor factor*, as it is termed by its inventor) is primarily intended for factories whic are driven electrically with the aid of water-power, but require steam fo heating purposes, as, for example, sugar refineries or distilleries. It consist

a cylindrical vertical boiler with a hermetically closed concentric cast-iron be inside. An arc is caused to play between a powdered graphite lining to e tube and a carbon rod suspended within it, the rod being passed air-tight rough a cover and insulated from the rest of the apparatus. The carbon d must always form the positive electrode, and, in use, it is screwed down ıtil it touches the graphite lining of the tube, and is then raised to strike the c, the resistance of the cold powdered graphite being so great that no short-rcuit is caused at the moment of contact. The graphite serves the further ırpose of protecting the metal of the tube from becoming overheated after-ards. During action graphite is constantly being deposited in the tube, ing transferred from the carbon rod (at the rate of 2 grm. per hour with an c of 60 amperes at 60–80 volts), so that any loss of graphite by combustion compensated for. A small valve allows for the escape of gas owing tot pansion at the moment of starting. An Ougrimoff boiler in the Paris xhibition (1900), 40 cm. high and 18 cm. in diameter, consumed 6 to 10 kw. 00 amperes × 60 to 100 volts) per hour and gave steam at a pressure of kgrm. per sq. cm., the efficiency being stated as 98 per cent. To compare ith ordinary usage the author makes a calculation purporting to show tha e cost of a calorie produced by steam heat in a part of a factory at a distance om an ordinary boiler may be 0·26 centime, whilst that of a calorie produced / the calorifactor is 0·17 centime, valuing electrical energy at 1·5 centimes r kw.-hour. W. G. M

227. *High-Tension Condensers.* **L. Lombardi.** (Elettricità, Milan, 19. 628–630, Oct. 6, 1900. Paper read before the International Electrical Con-ess at Paris.)—The author has found a method of preparing paraffin wax eets which, though thin, are perfectly homogeneous. Sheets 36 × 49 cm. and 2 mm. thick were tested at 17,000 volts, and made up into ten condenser ctions of fifty sheets each. The sections are contained in a box of paraffined ood immersed in paraffin oil; they are connected up in two series, each ving a capacity of ½ mf., and capable of withstanding 5,000 volts as a rking pressure. These can be connected in parallel or in series, giving mf. for 5,000, or ¼ mf. for 10,000 volts. Each section was tested at 9,000 lts for three hours. The rise of temperature as measured by a thermo-uple after ten hours at a pressure of 5,000 volts was, at the centre of the eets, 1·4° C.; at the edge 3·2° C. Measurements by the three-voltmeter method owed a loss of 100 watts in the condenser at 50 ∿.

The author gives examples showing the saving of energy not only in the e but also in the generator, when a condenser is used to increase the power-tor in a power transmission plant [see also Abstract No. 306 (1900)].

G. H. B.

228. *Graphical Determination of Regulating Resistances.* **E. Hunke.** lektrotechn. Zeitschr. 21. pp. 801–805, Sept. 27, 1900.)—The author develops number of graphical methods for determining the consecutive sections of a gulating resistance required to fulfil given conditions. The first part of the per deals with regulating resistances which are inserted into the main cuit, while the second part is devoted to the resistances used in the shunt cuits of dynamos or motors. In the case of the latter problem the open cuit and external characteristics of the machine must be known, and by king use of these curves the problem may be readily solved by the graphical thod explained by the author. A. H.

229. *Feeder Regulators.* **E. Stadelmann.** (Elektrotechn. Zeitschr. 2 pp. 285–288, April 12, 1900.)—The author considers the problem of designin a feeder-regulating resistance so that the fall of potential along the feeder an this resistance may be kept approximately constant within given limits, th maximum and minimum values of the feeder current being known. Curve are given for finding the number of contacts which must be provided for give ratios of the maximum to the minimum current, and for various values of th permissible variation in the drop along the feeder and regulating resistance. A. H

230. *Automatic Alternating-Current Brakes.* **J. Fischer-Hinnen.** (Elek trotechn. Zeitschr. 21. pp. 767–770, Sept. 13, 1900.)—The great advantage o automatic electromagnetic devices for applying the brake in the case of crane lifts, &c., consists in the fact that the brake is applied or lifted at the precis instant required, viz., when the current is switched off or on. In most of th automatic devices hitherto used a solenoid is employed for lifting the brak off the pulley. The dimensions of this form of apparatus cannot, however, b easily calculated. The author describes a form designed by himself and use by Krizik, of Prague, which is intended for alternating currents, and consis of a fixed and a movable core, resembling the stator and rotor of an inductio motor. The two cores are provided with suitable windings, the windings o the fixed core being connected in series with those of the movable one. Th range of the angular movement is about 90°. In the normal or "on" positio of the brake, with no current through the automatic device, the relativ position of the two cores is such that a current sent through them woul produce fields at 90° to each other. In the application of this device to a ordinary band-brake a crank keyed to the shaft of the movable core release or applies the brake according to the direction in which the core is move round. The author works out the theory and deduces formulæ for this typ of apparatus. **A. Kolben** (Elektrotechn. Zeitschr. 21. p. 854, Oct. 11, 190 compares the performance of this brake with that of a solenoidal one, th result of the comparison being to show that the solenoidal brake is much th lighter, simpler, and cheaper of the two. A. H

231. *Aluminium as an Electrical Conductor.* **J. B. C. Kershaw.** (Ele trician, 45. pp. 669–671, Aug. 24, and 741–743, Sept. 7, 1900.)—The author draw attention to the vigorous manner in which the Pittsburg Reduction Compan have pushed the use of aluminium for electric conductors since 1897, an have supplied large quantities at the low price of 1s. 2½d. per pound. O this side of the Atlantic no large installation of electrical power exists i which aluminium has supplanted the use of copper. In the United State however, transmission lines varying from 20 to 40 miles in length hav been erected, carrying 1,000 to 5,000 h.p. at 10,000 to 20,000 volts. Th author considers the question of the relative values of copper and aluminiu for electric conductors to be one upon which it is at present impossibl to express a definite opinion, and states that in the article to which th Abstract refers he has gathered together all the recently published fac and figures relating to the use of aluminium as an electrical conductor, an has supplemented these figures in some cases with figures of his own.

The relative conductivity of 99·6 per cent. aluminium, taking copper a 100, is 61·5 according to Northrup, and 60·5 according to Kelvin. Fo practical purposes these figures are useless, as aluminium is always alloye

vith copper or iron to increase its strength. This causes a considerable eduction in the conductivity as follows :—

Aluminium with 0·50 per cent. copper	58·16
„ „ 0·75 „ „	56·37

'he author's figures for the conductivity of aluminium wire supplied to him or experimental purposes by firms in this country are (copper = 100)—

No. 1 wire	Al. 51
No. 2 wire	Al. 54

.ttention is drawn to the great variation in the strength (tensile) of aluminium ccording to the amount of alloy present and the extent to which it has been nnealed.

From samples of aluminium wire supplied to the author he has obtained ıe following results :—

No. 1, 99 per cent. aluminium, tensile strength			32,480	lbs.	per square inch.
No. 2, alloy with 1 per cent. iron	„	„	38,080	„	„
No. 3, composition not stated	„	„	34,600	„	„

'he breaking-strains fixed by the authorities for overhead electric wires in ifferent countries are—

United Kingdom	31,360	lbs.	per square inch.
United States	32,000	„	„
France	31,218	„	„

Aluminium wire should therefore be alloyed with enough copper to give a tensile strength of 32,000 lbs. per square inch. This has been attained on ıe Stockholm line with 0·30 per cent. copper.

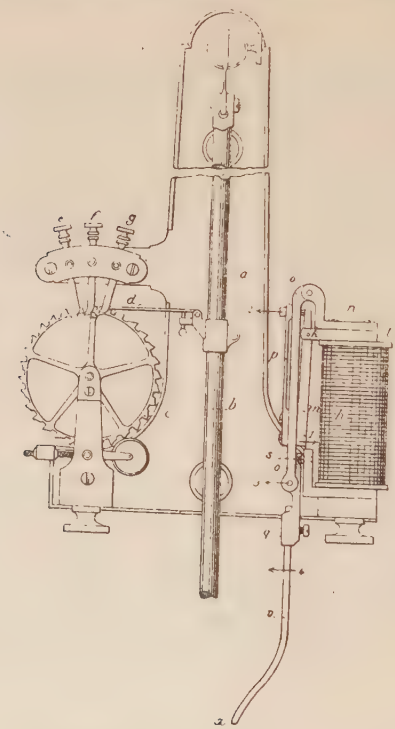
The Pittsburg Reduction Company have produced a wire with a tensile rength of 65,000 lbs. per square inch, but the conductivity was only 50 per cent. f that of electrolytic copper. Taking the practical conductivity of aluminium ire at 59·9 and the price of copper at 9d. per lb., the relative cost of uminium to copper works out as 100 : 123 for equal capacity. It is quite robable that the extra trouble involved in erecting aluminium wires may iminish this saving in the material.

The author gives a table of the more important transmission schemes in hich aluminium has been used. In spite of this considerable use it seems o be a most doubtful point whether or not aluminium possesses all the haracteristics of a suitable metal for overhead work. E. C. S.

232. *Electric Driving of Looms.* (Génie Civil, 37. pp. 400–401, Sept. 29, 900.)—This is a description of the gearing employed with an induction otor. In order to change the speed to suit the work in hand the motor alley is altered when driving by belt, while if toothed gearing is used the nion is changed, the distance between centres being suitably adjusted by a mple eccentric device. Both arrangements are illustrated. A. H. A.

233. *Campiche electrically-maintained Pendulum.* G. Dary. (Électricien, . pp. 179–180, Sept. 22, 1900.)—This pendulum is of the kind in which a nall weight or a spring is displaced at each closure of the circuit and then leased, this weight or spring acting on an arm fixed to the pendulum and mparting energy thereto. On the frame *a* are fixed the three principal parts

of the apparatus, viz., the wheelwork *c*, the pendulum *b*, and electromag
device *h x*. The pendulum *b*, which beats seconds, is provided with a st
steel *d* terminated by an anchor, and capable of being adjusted by mea
a slide and an adjusting screw. At each oscillation of the pendulum tow
the wheel *c*, this strip causes the wheel to turn through an angle corresp
ing to one tooth, and as the wheel has sixty teeth, it makes one revolutio
a minute. The wheel *c* also bears at the end of one of its arms a s
platinum pin which, once each revolution, touches two platinum conta



during 0·8 second, and thereby completes a circuit, including a source
electrical energy and the electromagnet *h*. A small balanced wheel acts
the lower part of the wheel *c*, and serves as a jumper. The other conta
e and *f* can be used for controlling secondary clocks. The electromagnet
attracts and oscillates its armature *m*, and through the links *o q* the flexib
strip *v x* which acts on the pendulum *b* and imparts energy thereto duri
0·8 second, the flexible strip being immediately returned to its origin
position by an adjustable spring *p*.

C. K.

234. *Industrial Electromagnets.* **A. Guénée.** (Ind. Élect. 9. pp. 427–42
Oct. 10, 1900.)—An electromagnet is considered when the armature is
movement as a motor, and the rule is deduced that "when the armatu
moves with constant speed and produces a *constant variation of flux* the pu
is of constant value." Based on this reasoning a magnet has been design
of the ironclad type shown in the figure (Fig. 1). Inside is the movab
armature N, the upper portion EE′ DD′ being made of discs of iron; t

number and the distance between each of these may be regulated as desired. All types of armatures have been studied, and experiments have been made with different combinations of alloys to give various reluctances, but the form figured is the one which in general has proved most practicable. Experiments have been made with a registering dynamometer, which has indicated the effort at different parts of the armature path. With the same current

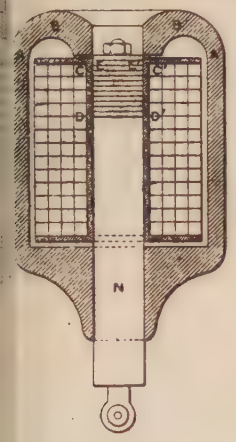


Fig. 1.

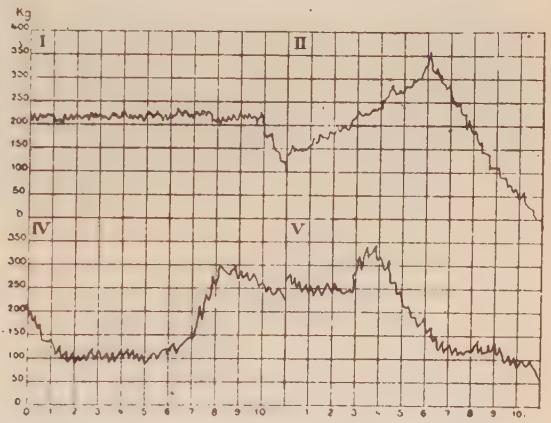


Fig. 2.

strength and the same magnet the curves shown in Fig. 2 were obtained by regulating the distances between the discs (the abscissæ represent travel of the core in cm.). The most powerful magnet constructed gives a constant effort of 650 kilos with a length of path of 22 cm., and required 30 amperes at 220 volts, the weight of the magnet and armature being 207 kilos. These magnets were exhibited at the Paris Exhibition. W. W. H. G.

235. *Calculation of the Diameter of Wire for Coils.* **A. Löwit.** (Elektrotechn. Zeitschr. 21. p. 881, Oct. 25, 1900; Elect. Engin. 26. p. 787, Nov. 23, 1900.)—The formulæ given correspond with the following, which are readily reduced :—

$$d = 1{\cdot}13\sqrt{\frac{\text{A.T.}\,\rho\lambda}{E}},$$

where d = diameter of wire in mm., A.T. = number of ampere-turns, ρ = resistance in ohms of a wire of length of 1 metre, having 1 sq. mm. sectional area, λ = mean length of a turn in metres.

For round spools this becomes—

$$d = 2\sqrt{\frac{\text{A.T.}\,\rho D}{E}},$$

where D = diameter of the mean turn.

This becomes for copper wire at 0° C.—

$$d = 0{\cdot}258\sqrt{\frac{\text{A.T.}\,D}{E}}$$

Using the current density, and taking account of the thickness of the insulating covering, we have (Uppenborn)—

$$(d+\delta) = \sqrt{\frac{\Delta\pi D l h \rho}{E}},$$

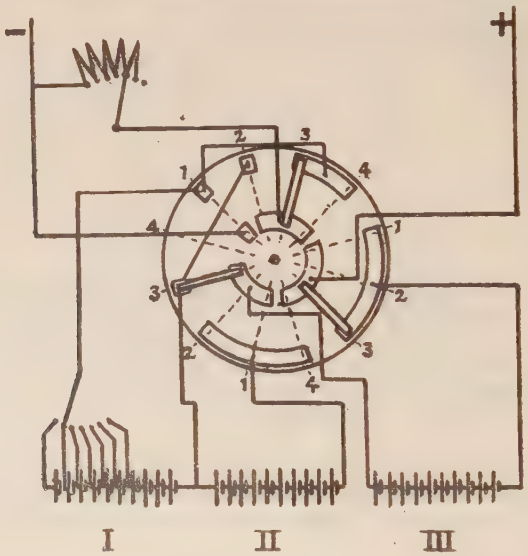
where δ = the double thickness of cotton, &c., Δ = current density in amperes per mm.^{2}, l = length of the winding space in mm., h = height of the winding space in mm.

This becomes for copper and round spools—

$$\Delta = 19{\cdot}2\frac{(d+\delta)^2 E}{D\,l\,h}.$$

W. W. H. G.

236. *Accumulator Switch.* **A. Löwit.** (Zeitschr. Elektrotechn., Wien, 18. pp. 505–506, Oct. 14, 1900.)—This switch is designed to permit accumulators to be charged from constant-pressure continuous-current street mains. For this purpose the battery is divided into three approximately equal sections, two of which are charged at a time. By this means the power to be wasted (at 110 volts) in the series resistance is reduced to about 13 per cent.



The switch, when in position 2 (see Fig.), permits Sections II. and III. to be charged; in position 3, Sections I. and III.; and in position 4, Sections I. and II. When in position 1 the switch permits the three sections to be discharged in series.

(The dotted lines in the Figure only indicate positions, not connections.)

C. K. F.

REFERENCES.

237. *Pollak Accumulators.* **J. Reyval.** (Écl. Électr. 24. pp. 441–445, Sept. 22, 1900.)—Particulars are given of the construction and mounting of the low discharge, high discharge, and traction type electrodes, together with useful data and curves relating to their electrical capabilities. E. J. W.

238. *Automatic Circuit Breaker.* **H. Müller.** (Elektrotechn. Zeitschr. 21. pp. 805 807, Sept. 27, 1900.)—A Schuckert circuit breaker is described which breaks when the current exceeds a certain limit, and if closed by hand will again automatically break if the current be excessive. The action of the apparatus is clearly illustrated by a diagram. E.K. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

239. *Apparent Increase of the Air-gap due to Slotted Armatures.* **C. F. Guilbert.** (Ind. Élect. 9. pp. 377–379, Sept. 10, 1900.)—The author takes points on the polar face opposite the middle points of two consecutive slots, joins these points to the edges of the tooth between them, and produces these lines to meet at a point inside the tooth. He then makes the supposition that if we draw lines from this point through the air-gap these lines will be the direction of the lines of force. If l be the distance between the two points on the polar face, l' the breadth of the tooth, and δ the mechanical clearance, then on the above supposition the apparent air-gap δ' will be given by the equation—

$$\delta' = \frac{l}{2} \frac{\log \frac{l}{l'}}{\log \left\{ \frac{l-l'}{2\delta} + \sqrt{1 + \left(\frac{l-l'}{2\delta}\right)^2} \right\}}$$

For example, if the mechanical clearance of a continuous-current dynamo be 0·5 cm. and the breadth of a slot equals the breadth of a tooth, and l' equals 1 cm., so that l practically equals 2 cm., then by the above formula $\delta' = 0{\cdot}785$. The formula can be at once extended to the case of alternating current motors where both the stator and rotor have slots. A numerical example for this case is worked out. A. R.

240. *Lanhoffer Dynamo.* **E. J. Brunswick** and **M. Aliamet.** (Électricien, 20. pp. 198–205, Sept. 29, 1900. Translated and commented on in the Elect. Engin. 26. pp. 512–515, Oct. 12, 1900.)—If we increase the excitation of a direct-current dynamo we can increase the voltage, but the practical limit to this increase is soon reached owing to magnetic saturation. On the other hand, if we diminish the excitation, keeping the current in the armature constant, there will soon be excessive sparking at the brushes. For example, an ordinary dynamo designed to give a voltage of 120 at a certain current can usually work fairly well when giving 100 or 150 volts. at this current. We may therefore say that it has a voltage coefficient of 1·5. The dynamo designed by E. Lanhoffer has a voltage coefficient of about 5. One of the uses of such a dynamo is to charge the accumulators carried by railway carriages. The trains may be of different lengths, hence the voltages required for charging are very variable. In the Lanhoffer dynamo there are two distinct magnetic circuits. The excitation of one of these fields is kept practically constant and if acting alone would produce at the terminals of the armature a voltage E. The excitation of the other field can be varied, and it produces a voltage which lies between the values $+e$ or $-e$, so that the voltage of the machine can be varied between $E + e$ and $E - e$. The regulation of the excitation is effected by a rheostat and reversing key. It is known how to construct dynamos so that they work fairly well at all loads without moving the brushes. The authors state that these principles are made use of in the construction of this dynamo. By a slight modification it can be turned into a motor-generator, and plans and all details are given of Lanhoffer machines of this type. They are in fact continuous-current transformers having a variable ratio. A. R.

241. *Construction of Dynamos.* **M. Leblanc.** (Electrician, 45. pp. 930–933, Oct. 12, 1900. Paper read before the International Electrical Congress at Paris.)—In every dynamo the useful fields are those which are interlinked with both the inducing and induced circuits. All other magnetic fields have a detrimental action, and hence it is desirable to reduce the leakage fields to a minimum by bringing the two circuits as close together as possible. This, in the author's opinion, can be best done by employing the same design for dynamos whether for direct or alternating current as is already used for machines of the induction type. One of the circuits will be wound in notches, cut in the internal surface of a ring, in the direction of the axis, and the other in similar notches on the external surface of a similar laminated ring concentric with the first and separated from it by a minute air-gap. The difficulty in making a direct-current machine of this type is that the magnetising force developed by the currents in the induced circuits is of the same order, so far as strength is concerned, as that developed by the inducing circuit, and hence, if constant voltage is to be maintained, the exciting current will have to be varied very considerably. To get over this difficulty the author winds a circuit on the field magnets, which is an exact reproduction of that on the armature and is in series with it, and hence the armature reaction is annulled. The absence of armature reaction would make it possible to increase the depth of the slots and so reduce the air-gap to the minimum required for mechanical clearance. The brushes of these machines would require no shifting and the weight of copper on the armature and field magnets would be practically the same. It would be possible to vary the voltages of these machines between the most extreme limits, as there would be no appreciable sparking.

The author then describes the principle of the compensating exciter which was exhibited by the Grammont firm at the Paris Exhibition [see Abstract No. 2100 (1900)]. A graphical proof is given of the method adopted of compounding an alternator for constant voltage ; when the inductances of the machine are constant the proof is rigorous. In conclusion the author lays great stress on the advantages to be gained by adopting the induction type of machine as the standard. He has shown that it is perfectly easy to obtain automatic regulation of the exciting current. He considers that the Grammont alternator and compensating exciter demonstrate — (1) the automatic excitation of this type of machine ; (2) that it gives a constant voltage at all loads and power factors ; (3) that the brushes of the exciter wear exceedingly well ; (4) that machines of this type run perfectly in parallel with machines of other types. A. R.

242. *Tendency of Modern Dynamo Design.* **W. Cramp.** (Elect. Engin. 26. pp. 475–477, Oct. 5, 1900.)—Conclusions are drawn from the machines shown at the Paris Exhibition as to the types of field magnets, armatures, &c., that are becoming the standards. Figures are quoted to show the close agreement in overall dimensions of machines by various makers. The standard field frame is the circular shape with inwardly projecting radial poles. The material for the field is almost always cast steel, which gives the machines a very light and neat appearance, when contrasted with those made with cast-iron frames. Drum armatures were nearly universal and slotted stampings were nearly always used for the core. The armatures of all the alternators shown contained iron. The alternators were all of the flywheel type, and in nearly every case the field revolved. Alternators in which the revolving field magnets projected radially inwards from the extended fly-

vheel rim were much in evidence. Laminated pole-faces were not ncommon and some small machines had their field magnets laminated hroughout. A. R.

243. *Design of Large Tramway Generators.* **H. F. Parshall.** (Street Rly. Journ. 16. pp. 775–778, Oct., 1900.)—The author starts by assuming an fficiency of 94 per cent., the losses being allocated as follows:—

C^2R loss in armature.....	2·25 per cent.
Core loss in armature	2·25 ,,
Field-magnet loss	0·75 ,,
Commutator loss C^2R and friction	0·75 ,,

he rise of temperature per watt per square inch at the periphery of an armature, should be 10° to 15° C. at 2,500 feet per minute, if measured by a thermometer, or 15° to 22° if measured by increase of resistance. In the field magnets he rise of temperature per watt per square inch should be about 60° by hermometer, or 120° by resistance, in the commutator about 15°. If the ise of temperature of any part is limited to 30° by thermometer, or 45° by esistance, the radiating surface per kw. output should be for the field 15 quare inches, for the armature 18·75 square inches, and for the commutator ·75 square inches. In calculating core loss, distortion, which may increase he maximum density 30 per cent., must not be lost sight of. The densities hould be taken so that the average armature core loss is less than 1 watt er lb. A curve is given showing watts per lb. at 7·5 cycles per second for ifferent densities. With carbon brushes the current density should not xceed 40 amperes per square inch. The contact resistance may be 0·03 ohm er square inch, or 1·2 volts drop from contact resistance. The pressure of ontact may be 1·5 lbs. per square inch, in which case, at 2,000 feet per minute, he mechanical friction is about 50 per cent. of the C^2R loss. The effect of esistance of brushes, self-induction of armature coils and frequency of eversal is discussed. Particulars are given of a General Electric Company's 50-kw. generator which has proved very satisfactory. R. B. R.

244. *Construction of Large Dynamos as Exemplified at the Paris Exhibition.* **. P. Thompson.** (Elect. Engin. 26. pp. 374–375; Discussion, p. 375, Sept. 4, 1900. Abstract of a paper read before the British Association.)—The two-ole type of machine so largely used in England was not exhibited by any ontinental firm except for very small motors. The copper type of alternator ith the armature built up of thin coils of bare copper was not represented. he alternators exhibited might be divided into four types—(1) Fixed external agnets and a revolving armature inside same (only a few exhibited). (2) tationary armature surrounding an internal system of magnet poles built up n a flywheel (large number exhibited). (3) Inductor type with no revolving onductors in either armature or field (very few exhibited). (4) Stationary rmature inside a revolving field-magnet system, the poles being bolted to he inner periphery of the flywheel rim (three machines exhibited). The ourth type is similar to some alternators made by C. E. L. Brown, for Cairo, ith the poles fixed inside the rim; the revolving mass of each pole tends to eep it in place and counteracts the magnetic pull. The Ferranti method of inding bare copper strip in an edgewise spiral for the exciting coil of field agnets is very largely used. The greater number of the alternators had wo slots per pole per phase; one large machine had only one slot; the . E. G. alternator (the largest in the Exhibition) had five slots, and there

was one machine with 2½ slots per pole per phase. With the increase in diameter of alternators the mechanical stability of the large rings is of importance. In one case the cast-iron frame was about 1 yard wide, whereas the length of the core was only 10 inches. In one of the Schuckert alternators the required stiffness was obtained by a number of stay rods secured to a ring of comparatively small diameter concentric to the shaft. Methods of compounding alternators are referred to, and also an unsymmetrical system of winding on a three-phase Ganz alternator.

The Russian branch of Siemens and Halske exhibited a direct-current dynamo in which the tendency to spark was kept down by arranging the inner surfaces of the poles so that they do not form a cylindrical surface concentric with that of the armature. The air-gap was smallest at the edge of the pole to which the armature conductors approached and largest at the edge from which they receded. In a Ganz direct-current dynamo unusually large teeth were found in the armature, there being only six teeth per pole. The poles had extended pole-pieces of laminated steel, some of the plates having the polar extensions cut off, so that the horns had a small cross-section of iron.

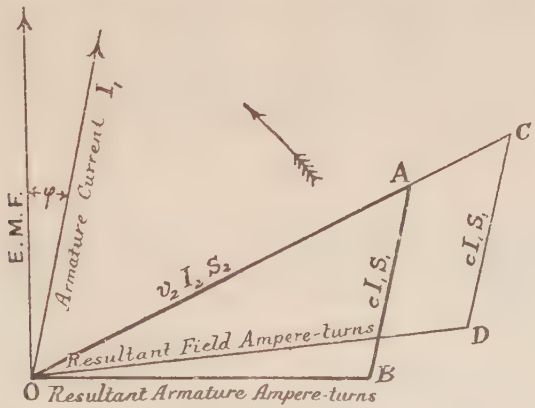
The Steinmetz formula (the diameter of the armature core multiplied by the length of the core, both in inches, divided by the output in kilowatts) gave a figure varying from 6, in bad designs, down to as low as 1½ for a well-designed 1,000-h.p. machine. E. K. S.

245. *Regulating Resistances for Shunt-wound Dynamos.* **E. Dick.** (Zeitschr. Elektrotechn., Wien, 18. pp. 489–493, Oct. 7. 1900.)—The author deals with the following problem : Given the open-circuit characteristic of a shunt-wound machine, to design a regulating resistance such that as the load varies the p.d. across the dynamo terminals may be kept within given limits by altering the resistance. Before attacking this problem it becomes necessary to determine the total e.m.f. corresponding to a given p.d. and armature current. The author does this for a machine in which the brushes have no lead, and then shows how the consecutive sections of the regulating resistance may be found by a graphical method. He then extends the result to a machine in which the brushes are given a forward lead. A. H.

246. *Experiments with a Motor Generator.* **W. E. Parker** and **F. W. Grover.** (Amer. Electn. 12. pp. 427–430, Sept., 1900.)—This is an account of some experiments with a motor generator for direct and alternating current. The alternator armature is fixed, built up of discs slotted inside. The field revolves inside the armature and consists of two five-pointed star-shaped castings mounted on the shaft, facing each other, with their arms interlaced, giving a ten-pole field with one exciting coil. The machine when tested did not give the expected result. The induction in various parts of the magnetic circuit of the direct-current motor was tested, and showed that only 55·55 per cent. of the induction in the field coils passed through the armature. A considerable part of the leakage went through the alternating armature. The induction in the alternating armature was tested, showing considerable variation in the different coils. Curves are given for the e.m.f. of different armature coils, showing considerable variation, not only between different coils, but also between successive undulations on the curve for one coil. This is explained by variations in the shape of the pole-pieces, and in the air-gap between a given armature coil and different pole-pieces.

R. B. R

247. *Theory of Alternators and Synchronous Motors.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 18. pp. 454-461, Sept. 16; 465-471, Sept. 23; and 514-518, Oct. 21, 1900.)—An important and suggestive contribution to the theory of alternators. The author points out the advantages which have resulted from considering the induction motor as a special case of the general alternating-current transformer, and develops a theory of the synchronous motor and alternator by regarding it as a particular case of the induction motor. According to this view an alternator is an induction motor which runs synchronously. The alternator armature is regarded as the primary or inducing circuit, and the field coils as the secondary or induced circuit. Since the slip is zero, the frequency of the induced currents is also zero—the current is, in fact, a continuous one, supplied by an independent source. The Heyland diagram for induction motors may therefore be applied to alternators, and by means of it many of the peculiarities in the behaviour of an alternator may be readily accounted for. The author next criticises the ordinary methods of dealing with armature reaction, and points



out the wide discrepancies which are in most cases found to exist between the results of experiment and deductions based on theory. He then states that such discrepancies very largely disappear if instead of dealing with magnetic fields we consider *ampere-turns*. The effective e.m.f. is regarded as due to the resultant armature ampere-turns. In the Figure let OC denote the exciting or field ampere-turns I_2S_2. On account of magnetic leakage only a certain fraction, $OA = v_2 I_2 S_2$, of the field ampere-turns will be effective in producing a flux through the armature. If with these "transferred" ampere-turns we compound vectorially the armature ampere-turns $AB = cI_1S_1$ (where I_1 = R.M.S. current and c is a coefficient depending on the number of phases and the wave-shape), we obtain the resultant or effective ampere-turns OB, the e.m.f. being in quadrature with OB. The author points out that the widely used method in which the mean arithmetical value of the armature current is considered in dealing with armature reaction is incorrect. The alternating armature ampere-turns may be analysed into two components, consisting of oppositely *rotating* ampere-turns of half the amplitude. It is then evident that the correct value of the current to be considered is half its maximum value. Accordingly, $c = qS_1 \frac{I_1}{2k}$, where q = number of phases, I_1 and S_1 = R.M.S. current and turns per phase respectively, and k = amplitude factor of wave (R.M.S. value ÷ maximum value). The value

of v_2 may be found from the short-circuit characteristic, and so long as this characteristic is a straight line the value of v_2 is constant. When the armature is short-circuited its resultant ampere-turns become vanishingly small, hence (see Fig.) $v_2 I_2 S_2 = c I_1 S_1$, and v_2 may be found. The author lays particular stress on the fact that v_2 will have different values for machines of the same type but with different numbers of poles, and that the value of v_2 for a polyphaser will depend on the number of phases in use. Assuming that the open-circuit and short-circuit characteristics of the alternator and the wave-shape [1] are known, we may, by the aid of the simple vector diagram shown in the figure, solve all important problems concerning alternators and synchronous motors. The author has tested the practical value of his theory by applying it to two widely different types of alternator, and the calculated results show remarkable agreement with the experimental ones, the divergence between the two being in most cases within 3 per cent. None of the methods hitherto in use have given such good results. A. H.

248. *Effect of Parallel Running of Alternators on the Shape of E.M.F. Waves.* **A. Pérot.** (Comptes Rendus, 131. pp. 377–380, Aug. 6, 1900.)—Suppose L and L^1 to be the self-inductances of the armatures of two alternators running in parallel which produce waves of e.m.f. differing from one another merely by the first having an extra term $E_n \sin(n\omega t - \phi_n)$, then if we can neglect the resistances of the armatures the author says that the difference of potential between the bus-bars due to this term will be $E_n \frac{L'}{L + L'} \sin(n\omega t - \phi_n)$. Hence if L′ be small compared to L the resultant wave between the bus-bars is nearer to a sine curve than the wave of the first alternator is. If we couple a synchronous motor whose armature has small self-inductance (l) to an alternator of large self-inductance (L) then the effect is the same, the harmonics being reduced in the ratio $\frac{l}{L + l}$. Synchronous motors thus make the p.d. wave more like a sine curve. In the author's opinion it would be prudent in order to avoid annoying effects from higher harmonics never to put an alternator on to the bus-bars or take one off without the protection of a synchronous motor in the central station. The effect on the wave form of putting an alternator of small self-inductance in parallel with one of large self-inductance is very striking. In an experiment the ratio of the maximum e.m.f. of an alternator to its effective e.m.f. was 1·65 ; when a small alternator was put in parallel with it, the ratio of the maximum p.d. at the terminals to the effective p.d. was reduced to 1·436. In a sine curve this ratio is 1·414. A. R.

249. *Eliminating the Harmonics from E.M.F. Waves.* **G. Claude.** (Comptes Rendus, 131. pp. 613–615, Oct. 15, 1900.)—One way of doing this is to use synchronous motors having feeble self-inductances, as suggested by Pérot [see preceding Abstract]. This risks bringing in new harmonics. The author suggests putting in an inductive coil and a capacity in series between the terminals of the alternator, the capacity being chosen so that resonance takes place at the frequency of the harmonic it is desired to suppress. This resonant circuit will have practically no effect on the fundamental of the e.m.f. wave. The author experimented on an alternating network in Paris with unsatisfactory results owing to the constant breaking down of the condensers. This,

[1] The author finds that, in spite of considerable changes in the wave-shape with the nature of the load, the amplitude factor k does not change much in a given type of machine.

he thinks, can be got over by using Lombardi's condensers. Getting rid of the harmonics from e.m.f. waves diminishes the danger from condenser shocks from the mains. The author previously proposed (Comptes Rendus, Nov. 20, 1893, p. 689) to get rid of the earth capacity of the mains by means of inductive coils. It would be advisable to make the networks as safe as possible, seeing that the number of fatal accidents is increasing every year.

A. R.

250. *E.M.F. of Alternators on Open Circuit.* **C. C. Hawkins.** (Elect. Rev. 47. pp. 655–656, Oct. 26 ; 691–694, Nov. 2 ; and 857–860, Nov. 30, 1900.)—In predetermining the e.m.f. which an alternator will give when run at a certain speed, it is customary to use the equation—

$$E = K \cdot 2Z_a \times \frac{pN}{60} \times \text{No. of inductors in series} \times 10^{-8} \text{ volts},$$

where Z_a is the total number of lines entering the armature from one pole, and $\frac{pN}{60}$ is the frequency due to the p pairs of poles. Now the factor K depends on the "form factor," *i.e.*, the ratio of the effective e.m.f. to the average e.m.f., and on the "width coefficient," or the ratio of the average e.m.f. to the gross average e.m.f., when differential action is supposed to be absent. In the

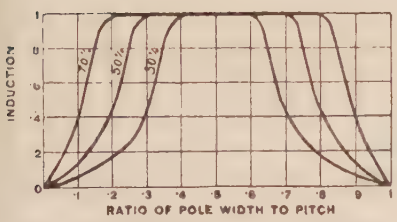


Fig. 1.—Flux-Distribution along Pitch-Line.

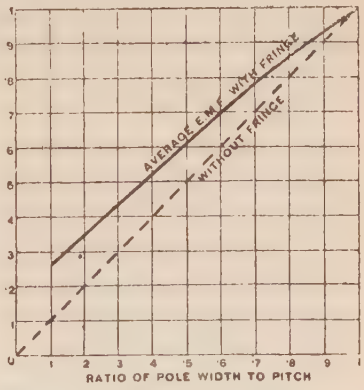


Fig. 2.—Average E.M.F.

calculation of K it is usually assumed that the flux from one pole face is confined to the width of the pole face. In this paper the fringe of lines, which must necessarily surround the actual pole face, is taken into account. To get these lines the method used by F. W. Carter [Abstract No. 2101 (1900)] is employed.

The three curves in Fig. 1 illustrate the flux distribution when the air-gap is one-twentieth of the pitch, and the pole width is 0·7, 0·5, and 0·3 of the pitch respectively.

In Fig. 2 the dotted line is the curve giving the average e.m.f. neglecting the fringe, and the full line when it is taken into account. The case of an alternator with slotted armature is next considered, and tables and diagrams are given for the net average e.m.f., the effective e.m.f., the form factor, and K for one, two, three, and four slots per pole respectively, these slots being equally spaced over the pitch.

When there are several slots per pole the curves showing how the ratio of

the maximum to the effective e.m.f. varies have several maxima and minima values, corresponding to certain values of the ratio of the pole width to pitch. The effect of the fringe of lines is to smooth out the curves of this ratio, so that there are no abrupt changes of value. They show, however, that sometimes a very small difference in pole width produces a great difference in the value of the ratio.

The following values, suitable for three- and two-phase machines, illustrate the tables given :—

VALUE OF K WITHOUT FRINGE.

Two Slots per Pole and per Phase.	Ratio of Pole Width to Pitch.				
	0·1	0·3	0·5	0·7	0·9
One-sixth of pitch apart	2·235	1·55	1·23	1·12	0·983
One-fourth of pitch apart.....	2·235	1·393	1·225	1·08	0·93
VALUE OF K WITH FRINGE.					
One-sixth of pitch apart	1·315	1·238	1·13	1·05	0·966
One-fourth of pitch apart.....	1·24	1·193	1·102	1·02	0·915

Very complete tables are given for a smooth-core armature, taking the fringe into account. The author discusses the question of the best values for coil and pole width in single-phase alternators, and concludes that the best proportion cannot be determined by any mathematical law, but must remain a matter for practical compromise. A. R.

251. *Shape of the E.M.F. Waves of Alternators.* **L. A. Herdt** and **E. M. Archibald.** (Canad. Elect. News, 10. pp. 171–173 ; Discussion, p. 156, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—A description is given of experiments made at the McGill University on the shape of the e.m.f. waves of two alternators at various loads and power factors. One of the alternators had a revolving field and a distributed winding on the armature, and the other was an inductor dynamo with a concentrated winding and badly designed inductor lugs. Diagrams are given showing the distribution of the lines of force over the pole faces, the shape of the e.m.f. waves at no load and with lagging currents at various outputs, &c.

At full load and unity power factor the e.m.f. is moved about 10 degrees from that at no load in the direction of rotation. As the power factor is decreased, the current lagging, this displacement is reduced until with a power factor of 0·55 the e.m.f. wave is nearly back to its original position at no load. The change of shape of the e.m.f. wave of the inductor machine as the power factor is varied is very much more pronounced. There is but little resemblance between the shape of the waves when the power factor is unity and when it is 0·95. Several synchronous motors were in turn operated from a generator whose wave form was varied by changing the character of the auxiliary load. In every case dissimilarity of wave increased the idle current and also the energy absorbed. The tendency to fall out of step on slight provocation was very marked with dissimilar waves. The authors state that they undertook the experiments to see whether it was possible to introduce a clause relating to wave forms into alternator specifications. They are still experimenting on the subject, and this paper is only preliminary.

Discussion.—**A. A. Dion** stated that to those engineers who were accustomed to look upon the sine curve as approximately correct in alternating current calculations the results obtained were somewhat startling. **P. G. Gossler** said that frequently the demagnetising effect distorted the magnetic field so as to throw the maximum e.m.f. further than 15 degrees one way or the other. He regarded the small distortion as an individual characteristic of the machine. In his opinion the curves showed that the machine was a very good one. **L. A. Herdt** in his reply said that the machine was a very good one. A. R.

252. *Distribution of Magnetic Flux in Alternators.* **C. Westphal.** (Elektrotechn. Zeitschr. 21. pp. 878 881, Oct. 25, 1900.)—The author applies the method previously used by him in connection with continuous-current dynamos [see Reference No. 2324 (1900)] to alternators, and gives diagrams showing approximately the distribution of the induction round the periphery of the alternator field magnet due to the field excitation. By an integration of these curves the instantaneous values of the impressed flux traversing the armature coils are obtained. The author next establishes an equation connecting the total actual flux through the armature coils with the number of turns in the exciting and armature coils, and the instantaneous values of the exciting and armature currents. The equation is next simplified by supposing that the armature has a smooth core, and this simplified equation is used for plotting the armature current-wave by a step-by-step process of graphical integration. The results obtained show that the frequently made assumption of a constant armature inductance is—even in the case of smooth-core armatures—not justifiable. The concluding section of the paper deals with the effect of magnetic leakage. A. H.

253. *Power Factor in Central Station Work.* **F. H. Leonard, Jr.** (Canad. Elect. News, 10. pp. 173–175; Discussion, pp. 157–159 and 165–167, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—Diagrams of the e.m.f. and current waves of a transformer at no load and full load are given to illustrate that the closer the resemblance between the e.m.f. and current waves, and the nearer they approach one another, the higher will be the power factor. By increasing the field excitation of a synchronous motor we can introduce leading currents into a network which will help to counterbalance the lagging currents due to arc lamps and induction motors. This is sometimes a convenient way of overcoming line-drop and poor power factor. Synchronous motors, however, are only possible with steady loads. A single synchronous motor subject to sudden load variation defeats all attempts at good regulation of the system. The author is altogether in favour of induction motors as against synchronous motors. When alternating-current enclosed arc lamps with compensating coils are used the power factor of the circuit is low. Ordinary alternators are not suitable for loads with low power factors. The best modern alternators give an inherent regulation indicated by a short-circuit current of at least three or four times the full-load current; the change in the excitation at full load and 0·8 power factor is not more than 20 per cent.; they can stand an overload of 25 per cent. for six hours, and one of 50 per cent. for one hour, without overheating. These alternators are excellently adapted for motor work. A power factor considerably less than unity is now regarded as a necessary evil consequent on the opening up of a new and lucrative branch of the industry, and engineers would do well to take it into account in their calculations.

Discussion.—**L. A. Herdt** said he thought that with a proper adjustment of the field excitation of a synchronous motor the power factor might be made to approach very closely to unity. **F. H. Leonard** replied that theoretically this was possible, but in practice it was impossible, as when a synchronous motor is over-excited beyond a certain limit a flickering of the voltage over the whole circuit occurs. **P. G. Gossler** said that a power factor of unity could be obtained, but that in practice it corresponded to a very unstable condition of working. He regarded synchronous motors as almost indispensable adjuncts in central station working. In the arc-light system at Buffalo the power factor is kept at 0·97 or 0·98 by their means. He laid stress on the fact that in the operation of induction motors it is necessary to regulate the generator excitation in order to compensate for changes in the load on the motors. **H. R. Leyden** said that in his station he is changing over all the direct-current arc lamps into enclosed alternating-current lamps. Thirty of these lamps are run in series at a pressure of 2,400 volts. The power factor of the lamp circuit is 0·85. He concluded by stating that for large motors which will run on steady loads he would use synchronous motors, but for distributing power in a factory he would prefer to use induction motors. A. R.

254. *Induction Motors with Large Starting Torque.* **M. Déri.** (Ind. Élect. 9. pp. 425–427, Oct. 10, 1900.)—The principle underlying the construction of these motors has already been briefly explained [see Abstract No. 1285 (1898)

FIG. 1.

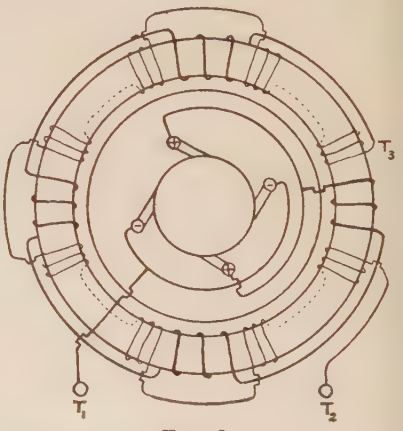


FIG. 2.

and Abstract No. 2320 (1900)]. The present paper describes a number of methods suitable for use with single-phase induction motors. In Fig. 1 is shown a form of winding suitable for a single-phase motor whose stator windings may be coupled up so as to produce either a four-pole or a six-pole field. The necessary change of connections may be effected by means of a suitable switch. At starting a four-pole field is used, and it will be noticed that the rotor winding behaves like an ordinary Gramme winding in a four-pole field. When the motor has run up to speed the connections are changed so as to give rise to a six-pole field. In such a field each pair of diametrically opposite coils consists of two coils moving under pole-pieces of opposite polarity, and hence having e.m.f.'s induced in them which act in the same direction round the local circuit formed by the two coils; the resistances r

inserted between the junctions of opposite coils and the commutator segments now not conveying any current. The brushes may now be short-circuited and lifted off the commutator. The winding shown in Fig. 1 is equally applicable to a polyphase motor, in which case the brushes and commutator are entirely dispensed with, their place being taken by a simple continuous ring which connects all the junctions of the resistances r. The two numbers of poles may be chosen in a great variety of ways (*e.g.*, 4 and 6, 6 and 8, 8 and 12, &c.), the only restriction being that the greatest common factor of the two numbers should be an even sub-multiple of one number of poles, and an odd sub-multiple of the other number. Fig. 2 shows another arrangement which has been used. It may be described as a combination of an eight-pole induction motor with a four-pole series-wound motor, and instead of using first a four-pole and then an eight-pole field (as would have been the case with a motor of the type just described, Fig. 1), *both* fields are used simultaneously at starting. At the instant of switching on, the p.d. across the eight-pole stator winding (*i.e.*, between the points T_3 and T_2) will, on account of the low impedance of this winding, due to the presence of the short-circuited rotor winding, be very small, and the four-pole winding (thick lines) will receive a high p.d. As the motor runs up to speed, however, the p.d. across the eight-pole winding increases, while that across the four-pole one decreases. When the normal speed has been reached, the terminals T_1, T_3, are connected by a short-circuiting switch, and the brushes lifted off the commutator. The author states that motors of this type have been used in Vienna and Budapest and have given satisfaction. A. H.

255. *Measurement of Slip of Induction Motors.* **W. H. Browne, Jr.** (Elect. World and Engineer, 36. p. 574, Oct. 13, 1900.)—Two revolving contacts are fixed, one to the shaft of the generator, the other to that of the motor, and are arranged to break contact at one point of the revolution. These two are joined in parallel across a circuit consisting of a battery and a single-stroke bell arranged to ring when the armature is released. The bell will then ring only when the two contacts are broken simultaneously, which will occur at every complete revolution lost by the motor. G. H. B.

256. *Alternating-Current Motors.* **J. Buchi.** (Écl. Électr. 25. pp. 151–155, Oct. 27, 1900.)—The author points out the conditions which alternating-current motors should satisfy in order to meet the requirements of the consumer as well as the suppliers of electrical energy. The theory of the effect of inserting non-inductive resistances into the rotor circuits is discussed geometrically by a diagram attributed to Heyland. It is shown that the insertion of resistance into the rotor circuits not only increases the starting torque but also, for a motor of given output, diminishes the effective number of turns. The author also states that a high-starting torque is obtained by having the induction density in the iron high. W. G. R.

257. *Experiments with Rotary Converters.* **A. G. Grier** and **J. C. Hyde.** (Canad. Elect. News, 10. pp. 175–179, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—Diagrams are given of the e.m.f. waves at the terminals of a rotary converter at various loads. These curves illustrate that the effect of armature reactions on the wave form is hardly noticeable. The question of the compounding of rotaries to keep up the direct-current voltage when the load comes on is considered. Problems connected with the regulation of rotaries in street railway work are

solved both graphically and analytically. Experiments on inverted rotaries, *i.e.*, rotaries used to convert direct into alternating current, are also described. A lagging current load makes an inverted rotary speed up, whilst a leading current makes it slow down. Hence with lagging currents we need to strengthen the field if the rotary is to revolve uniformly. This could be done automatically by driving the exciter off the shaft of the rotary—a method devised and put in practice by B. G. Lamme [Abstract No. 1575 (1900)]. The iron of the exciter should be worked at a low induction. Inverted rotaries are now employed to transmit power from large direct-current power stations to great distances. If an inverted rotary were fitted with a compensating exciter similar to that devised by Rice, of the General Electric Company, then theoretically the frequency of the current would be constant.

A. R.

258. *Transformer Core Ageing Tests.* **W. E. Goldsborough.** (Elect. Rev. N.Y., 37. pp. 395–396, Oct. 17, 1900.)—Two series of tests were made on five modern 60-cycle 5-kw. transformers from different manufacturers. The transformers were kept at full load for 9½ hours a day five days in the week, and allowed to cool to a temperature of about 26° C. during the remaining 14½ hours. On the other two days the periods of full load and of rest were 5 hours and 19 hours. The leading results are given in the following table :—

Hours at Full Load.	Core Loss in Watts.				
	A	B	C	D	E
0	85	74	95	72	91
350	83	73	91	70	90
822	83	74	91	69	92
(Interval of Eight Months.)					
822	85	75	93	74	93
1,403	81	73	88	73	96
1,700	79	76	85	74	95

Transformers A, B, and D are oil-insulated. A and B are of the "core" type, C is of the "shell" type. The values given in the table were selected from among all the values obtained as being those which conform most nearly to the actual average performance of the transformers during the tests. Intermediate readings were obtained in the case of four of the transformers, which showed a temporary spasmodic departure from the mean values.

W. H. E.

259. *Constant Potential Continuous-Current Transformer.* **F. W. Davies.** (Elect. Rev. 47. pp. 614–615, Oct. 19, 1900.)—A method is described of constructing a continuous-current transformer so that it will give at all loads a constant potential difference at the secondary terminals. It is applicable only to transformers of the single-field type where both the primary and secondary windings are wound on one core. The field magnets are provided with slots in which a compensating coil in series with the secondary circuit is wound so that the magnetism of part of the pole face is strengthened as the load increases. The primary coil on the armature is wound with a pitch large enough to enclose the whole armature flux, but the secondary coil is chord-

vound and its pitch is only large enough to enclose the whole of the lines of orce coming from the compensating coil. By this means it is possible to nake the ratio of transformation either increase as the load increases, or emain approximately constant at all loads. Diagrams are given of the nagnetic circuit and of the armature windings for a two-pole machine.

A. R.

REFERENCES.

260. *Designs for Double Current Generators.* **J. C. Brocksmith.** (Amer. Electn. 12. pp. 134–138, March ; pp. 186–188, April ; and pp. 228–231, May, 1900.)—Particulars and drawings are given of 1, 2, and 4 kw. machines, which, when suitably connected, will give the following : Direct current generator or motor ; single, two, or three-phase generator or motor ; rotary converter changing single, two, or three-phase current to direct current, and *vice versâ ;* phase transformer changing alternating current of one phase to that of any other phase. The windings give 110 volts direct current, 80 volts single or two-phase, and 70 volts three-phase, the periodicities being 60 or 125. E. K. S.

261. *Theory of Commutation.* **C. C. Hawkins.** (Electrician, 46. pp. 19–21, Oct. 26 ; and 44–46, Nov. 2, 1900 ; from a brochure published by the Electrician Printing and Publishing Company.)—This paper, which is based on the work of Arnold and Mie [Abstract No. 1084 (1899), is of a mathematical nature, and does not admit of a useful Abstract. A. H.

262. *Polyphase Railway Apparatus and Methods.* **L. Bell.** (Street Rly. Journ. 16. pp. 804–808, Oct., 1900.)—A description with illustrations is given of the development of the large direct-driven polyphase generator. Details are given of the stator of a 3,500-kw. direct-connected alternator for the Metropolitan Street Railway, New York [see Abstract No. 1372 (1900). The author points out that there are cases where the adoption of polyphase motors for tramway working would be very advantageous. A. R.

263. *Theory of Induction Motors.* **G. Ossanna.** (Elektrotechn. Zeitschr. 21. pp. 712–713, Aug. 23, 1900.)—A brief account of the author's graphical method of dealing with the problem of the induction motor. The method has already been referred to in Abstract No. 1781 (1899). A. H.

264. *Vector Diagram of Induction Motors.* **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 781–782, Sept. 13, 1900.)—The author critically examines the induction motor diagrams proposed by Heyland, Ossanna, and Kapp, and points out that so far as the secondary flux is concerned these methods all lead to different results. He then gives a construction of his own in which the difficulties connected with the other methods are got rid of. A. H.

265. *Diagram of General Alternating-Current Transformer.* **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 854–855, Oct. 11, 1900.)—A letter in which the author further discusses the vector diagram of the general alternating-current transformer, and replies to some criticisms passed on his previous letter, noticed in the preceding Abstract. A. H.

266. *Diagram of General Transformer.* **B. A. Behrend, K. Kuhlmann, J. Heubach,** and **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 875–876, Oct. 18 ; 894–895, Oct. 25 ; and 941–942, Nov. 8, 1900.)—Some further correspondence on the diagram of the general alternating-current transformer, and its relation to the induction motor diagrams of Behrend, Heyland, Blondel, and Ossanna. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

267. *Alternate-Current Working.* **H. S. Meyer.** (Elektrotechn. Zeitschr. 21. pp. 858-861, Oct. 18, 1900.)—This is a general review of the various systems having more especial reference to American as contrasted with Continental practice. The choice of frequency is discussed, and the usual arguments for and against high frequency are stated. As an example of low-frequency working the Brooklyn Edison Central Station is quoted. Here 1,500-kw. alternators are directly coupled to compound engines with a speed of 75 r.p.m. This gives with 40 poles 25 ∿ , whereas if 60 ∿ had been required 96 poles would be necessary. On the other hand, so low a frequency as 25 is unsuitable for lighting, and a "frequency changer" must be used. The Figure (see Fig. 1) shows the arrangement. It consists of a six-pole induction motor A, the armature of which is rotated by a four-pole synchronous

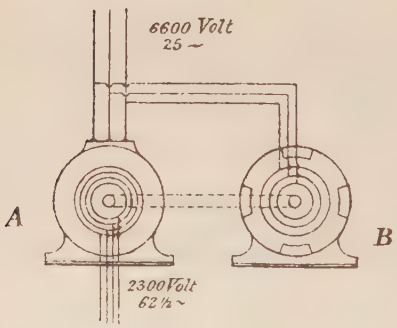


Fig. 1

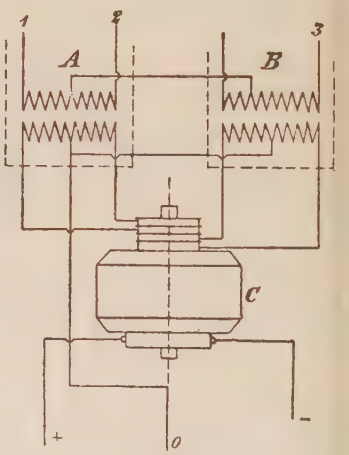


Fig 2

motor B. The supply at 6,600 volts 25 ∿ three-phase is transformed to 2,300 volts 62·5 ∿ two-phase. The normal speed of A is 500 r.p.m. of B 750 r.p.m. At the Chicago Edison Central Station 200-kw. 20-pole machines are used of the double-current type, enabling a direct current to be obtained from the low-frequency supply.

For electric furnaces, as in the manufacture of calcium carbide or carborundum, very low frequency values such as 10 to 20 may be used with advantage.

The "Monocyclic system" is described and discussed. This is essentially a single-phase system with a third or *teaser* wire for supplying power to motors. An explanation follows of the system invented by Scott. The use of six-phase currents is next discussed, and the arrangement of circuits for a six-phase transformer shown. Then follows an account of an interesting combination of

systems which the author has seen at the Utah Power Company in Salt Lake City, where a two-phase rotary transformer, by the use of Scott's arrangement, is supplied from a three-phase circuit. The arrangement is shown in Fig. 2. A and B are two transformers, C the rotary. The middle points of the two-phase windings are connected to the neutral conductor of the network.

The typical properties of synchronous and asynchronous motors are finally fully considered. W. W. H. G.

268. *Electrical Supply.* **C. P. Steinmetz.** (Elect. World and Engineer, 36. pp. 486–487, Sept. 29, and 529–530, Oct. 6, 1900. Paper read before the Association of Edison Illuminating Companies, Saratoga, Sept. 4, 1900.)—The usual system in America is the continuous-current three-wire system, with direct-coupled units, or pairs of 125-volt face-commutator machines. This type is the most economical of space, but for 250-volt machines the carbon brush separate commutator type is generally employed. Outlying districts are supplied with alternating current by belted or, occasionally, by direct-connected alternators. In these stations the storage battery has been successfully introduced. It is now becoming the practice to generate the power in one large station outside the town, using three-phase direct-coupled machines ; the power is transmitted at high pressure to substations, where it is transformed and converted into continuous current for the main distribution, alternating for outlying districts and pioneer work, and constant current for arc lighting.

As to frequency : incandescent lighting is feasible at 30 and satisfactory at 40 cycles ; arc lighting is feasible at 40 and satisfactory at 60, though still better at 125 ; rotary converters are feasible at 60 cycles, but perfectly satisfactory only at 25 cycles. In direct-coupled slow-speed alternators the lowest frequency is the most desirable. Where an appreciable part of the power has to be converted into continuous current the rotary converter is the most efficient and reliable apparatus to use. Assuming a voltage of 300, a peripheral speed of commutator of 3,000 feet per min., width of segment $\frac{3}{8}$ inch, and 10 volts per segment, we get 27 cycles as the upper limit of conservative converter design. Converters are in satisfactory operation at 60 or even 66 cycles, but only under favourable conditions as regards steadiness of power supply, low resistance of transmission line, careful attention to commutator, brushes, &c. The higher the frequency of a converter, the larger must be the number of poles. This requires that the armature reaction of the machine, considered as a continuous-current generator, must be high, to avoid cross-currents between the poles and unequal current distribution between the different sets of brushes of the same polarity, and consequent heating and sparking. With a machine of very low armature reaction, such as the 60-cycle converter (in which the space per pole on the armature is limited by the frequency), unequal current distribution may become serious. Also the high speed, and consequent high momentum, is apt to cause hunting. For these reasons it is very undesirable to adopt a higher frequency than 25 cycles for converter work, motor generators being preferable for conversion at higher frequencies. To suppress hunting the most efficient device is to use copper bridges between the field poles.

In the case of alternators running in parallel, experience has shown that a maximum difference in phase of 5 or 6 degrees is about the upper limit of good practice. This limitation is obviously much more difficult to secure with a large than with a small number of poles. It should preferably be secured by balancing the momentum of the reciprocating masses of the

engine against the steam impulses, and not by very large flywheel capacity, since this tends to cause hunting. While the speed during each revolution should be as uniform as possible, it is preferable that the speed should drop several per cent. from no load to full load to insure good division of load between machines working in parallel.

A double current generator used as a converter is more liable to hunting, and a converter as double current generator to sparking and heating. The converter should have a high armature reaction to secure high output and stability, and a small conductor section to secure best commutation. Wherever the substations can be reached with 6,000 to 10,000 volts it is preferable to use alternators giving that pressure, these being just as reliable and efficient as low-voltage machines. In the generating station the main cables and feeders should be separated in a number of different conduits as far apart as possible. The operating switchboard should have no high-pressure conductors on it; instruments can be supplied from transformers, and switches can be operated by relays.

In the chain—generator, transmission line, transformer, converter—the transformer is the weakest link as regards overload capacity, and consequently it is best to allow a liberal margin in this apparatus. Air-blast is the best system of cooling, oil being too sluggish. It is desirable to give each converter unit a separate bank of transformers, in order to prevent pulsating cross-currents between converters, with consequent sparking and heating. Transformers and converter should be connected together permanently by conductors of the least possible length.

To regulate the bus-bar voltage of the substation, the alternating pressure on the converter has to be varied. This can be done by a switch controlling the number of working turns of the transformer primaries, or by inserting a special boosting transformer with primary in shunt and secondary in series with the circuit. The secondary coil is movable, and the variation of voltage is thus perfectly gradual. This regulator has the advantage of giving by its self-induction a flexible connection between converter and generator.

If a storage battery is used, it may be connected to the bus-bars through a series booster, which adds to the station voltage in charging and to the battery voltage in discharging, acting as generator in either case.

For series arc lighting, with a 60-cycle generating system, it is preferable to use alternating arcs. With a 25-cycle system there is a choice of methods: (1) Arc-lighting dynamos driven by synchronous or induction motors. (2) Constant current transformers and rectifiers. (3) Motor alternators or frequency converters, with constant current transformers. (4) A motor-driven constant current alternator feeding a number of arc circuits from series transformers. By this system circuits of different voltage and different current can be supplied from the same machine, and this generator may be of large capacity, instead of a number of small units as required with other systems. W. H. E.

269. *Switching Arrangements for Polyphase Circuits.* **H. Passavant.** (Elektrotechn. Zeitschr. 21. p. 767, Sept. 13, 1900.)—A short article giving the results of a discussion at the recent Kiel meeting of the Verband Deutscher Elektrotechniker as to the advisability of providing a break for each conductor of a polyphase system. The question was unanimously answered in the affirmative, a motor or other apparatus when switched off not being regarded as safe unless completely disconnected from all the supply conductors. A. H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

270. *Barnsley Electricity Works.* (Elect. Engin. 26. pp. 402–410, Sept. 21, 1900.)—The station is worked by the Corporation, and was opened in February, 1900. *System:* Continuous current, three-wire, at 230 volts per side, with batteries. The *boiler-house* contains three Lancashire boilers 28 ft. by 7 ft. 6 in. diameter, working at 160 lbs. The feed-water is heated by a Royles feed-water heater capable of raising the temperature of 2,000 gallons per hour from 55° F. to 200° F.; thence it passes through a Green's economiser of 192 tubes and a Kennedy water-meter. The coal is fed by an elevator into a conveyer running above the boilers, which supplies the hoppers of the Vicars' mechanical stokers. The *engine-room* contains three 75-kw. and one 150-kw. direct-driven sets, by Willans and Johnson & Phillips. The large engine indicates 250 h.p. at 380 r.p.m. with a pressure of 150 lbs. per square inch; the small ones are of 100 b.h.p. at 450 r.p.m. They are all non-condensing, with a specified consumption at full load of 26 lbs. of steam per b.h.p. hour. The dynamos are four-pole, giving respectively 155 kw. and 75 kw. at any e.m.f. between 460 and 520 volts. The combined efficiency of the sets (e.h.p.: i.h.p.) was specified to be not less than 81 per cent. The equipment also includes a balancing set capable of dealing with 75 amperes, and two boosters for charging the batteries, each capable of giving 130 amperes at 75 volts. The dynamos are designed with a view to working on a future traction load. The accumulators, supplied by Pritchetts and Gold, consist of 260 cells in glass boxes; their capacity is 500 ampere-hours at 100 amperes, or 300 ampere-hours at 300 amperes.

The *feeders*, of which there are three sets, are single cables by the British Insulated Wire Company, each set of 0·5, 0·2, and 0·5 square-inch sections; they are the paper-insulated, lead-covered type, laid in earthenware troughs and filled in solid with bitumen. The distributing cables, which supply about six miles of streets, have sections 0·25, 0·15, and 0·10 for the outer wires, with middle wires of about two-thirds of these sections. Lamps to the number of 8,340 8-c.p. or their equivalent were connected in July, 1900, with fifteen 10-ampere arc lamps, and thirty 16-c.p. incandescent lamps for the public lighting. G. H. B.

271. *Carlisle Electric Tramways.* (Tram. Rly. World, 9. pp. 477–482, Oct., 1900.)—The system is overhead trolley, direct current at 500 volts with buffer batteries. Current is obtained from the City Supply Station at the following rates: For the first 50,000 units annually, 2d. per unit; for the next 100,000 units 1¾d.; and for further units 1½d. per unit. The length of track is 7¾ miles, consisting of 3¼ miles of single and 2¼ of double track. For the overhead line, side-pole construction is principally used, with a small amount of centre-pole work. The poles are of steel, drawn taper, 28 feet to 30 feet in length, with a diameter of 7 inches at the base. Cast-iron brackets support the trolley wire, which is run double throughout, and consists of No. 0 gauge with a breaking strain of 23 tons per square inch. The permanent way is laid with steel girder rails weighing 83 lbs. to the yard, at a gauge of 3 ft. 6 in. The rails are jointed by "Dicker" fishplates, and bonded by double Neptune bonds. The track foundation consists of 6 inches of cement and concrete, extending 2 feet outside the rails; the paving is of Whinstone setts. The feeders are Callender's vulcanised bitumen cables laid in Sykes' conduits; feeder pillars are arranged at half-mile intervals, each being in telephonic communication with the power station.

The rolling stock consists of 12 four-wheel motor cars, of which 9 are double-deck and 3 single-deck pattern; the bodies are built by the Electric Railway and Tramway Carriage Works, and are mounted on Brill 21-E trucks. The car length is 26 ft. 6 in., and the seating capacity of the double-deck cars is 43, and of the single-deck 22 passengers.

On the routes equipped there are no important gradients, the maximum being 1 in 14 for a distance of 60 yards; the curves are, however, sharp, the minimum radius being 40 feet. The erection of the whole plant has been carried out by Dick, Kerr & Co.

The plant erected at the Corporation Station is as follows: *Boiler-house:* Three Lancashire boilers 28 feet by 8 feet in diameter, by the Oldham Boiler Works Company, Limited. Each can evaporate 8,000 lbs. of water per hour at a pressure of 160 lbs. per square inch. They are fired by mechanical stokers by the Union Ironworks Company. The feed-water is heated by a Green's economiser of 384 tubes. *Engine-room:* Two 200-i.h.p. Willans-Siemens sets running at 350 r.p.m., and two of 100 i.h.p. at 460 r.p.m.; the latter are used as balancers. The larger engines gave the following tests: Pounds of water per i.h.p. at full load, 16·5; ¾ load, 17·2; ½ load, 18·0; ¼ load, 20·1; lbs. of water per e.h.p. at full load, 20·3; ¾ load, 22·3; ½ load, 25·2; ¼ load, 34·4. Each engine is fitted with a Ledward ejector condenser giving a vacuum of 26 inches of mercury.

There are now in course of erection two 400-i.h.p. Willans-Peebles sets running at 300 r.p.m.; they will be run compounded on the traction load and shunt on the lighting load. Also a booster by the Electric Construction Company, consisting of two 4·2-kw. generators mounted on either side of a motor. The voltage of all the generators can vary from 470 to 530 volts; their fields are separately excited at 230 volts. The secondary battery consists of 250 chloride cells in glass boxes. G. H. B.

272. *Glasgow Electricity Works.* (Electrician, 45. pp. 765–767, Sept. 14; 805–812, Sept. 21; and 849–852, Sept. 28, 1900.)—*System:* Continuous current, three-wire, at 250 + 250 volts, with batteries. In the Port Dundas station the *boiler-room* contains 10 Babcock and Wilcox boilers containing 4,020 square feet of heating surface and capable of evaporating 15,000 lbs. of water per hour at a pressure of 200 lbs. per square inch. They are fitted with Babcock and Wilcox superheaters. The steam main consists of a 15-inch mild-steel pipe. The feed-water is supplied by either a steam-driven or an electric motor-driven pump. Coal is stored in a 4,000-ton reserve bunker and in 60-ton steel tanks, one above the level of each boiler. It is fired by Babcock and Wilcox chain grates and mechanical stokers driven by electric motors. The clinker and ash is shot into an ash tunnel, from which it is removed by an electric tramway. The *engine-room* contains seven vertical sets. These are: (1) A 750-h.p. two-crank compound Ball & Wood engine with Corliss valves running at 150 r.p.m.; the cylinders are 20-inch and 44-inch by 24-inch stroke. (2) A 900-h.p. three-crank triple-expansion marine engine by Matthew Paul & Co., running at 120 r.p.m., with cylinders 17-inch, 25½-inch, and 38-inch by 30-inch stroke. (3) A 400-h.p. four-crank triple-expansion single-acting constant-thrust enclosed engine by the Mirrlees, Watson & Yaryan Company, running at 330 r.p.m. with cylinders 14-inch, 22-inch, and two of 24-inch by 24-inch stroke. (4) A 200-h.p. two-crank compound engine of similar type, running at 380 r.p.m., with cylinders 12-inch and 14-inch by 12-inch stroke. (5) and (6) Two 1,100-h.p. triple-expansion Belliss engines with one h.p., two i.p., and three l.p. cylinders on three cranks, and

piston valves; speed 230 r.p.m. The engines are designed for an overload of 1,500 h.p. and have by-pass valves for this purpose. (7) One 1,100 Willans three-crank triple-expansion engine with similar provisions for overload as the Belliss engines. The condensing plant consists of five sets of independent surface condensers by Allen. Each has a cooling surface of 2,550 square feet. Engine No. 1 is directly coupled to two dynamos by the Walker Manufacturing Company. They are compound-wound eight-pole 250-volt machines and are used as balancers. Engine No. 2 drives directly a twelve-pole shunt-wound Schuckert dynamo. Engines 3 and 4 drive directly two shunt-wound two-pole Crompton dynamos, their outputs being respectively 125 kw. and 255 kw. at 500 to 600 volts. Engines 5 and 6 are direct-coupled to British Thomson-Houston compound-wound multipolar dynamos giving 500 to 600 volts. Engine 7 drives directly a Crompton twelve-pole compound-wound dynamo; the field magnets are of cast steel with laminated poles. The three last dynamos have throw-over switches enabling the series coils to be cut out. There are two motor balancers, namely, a four-pole 250 kw. Bruce-Peebles set and a two-pole 50-kw. Silvertown set; the latter is compound-wound and gives 150 amperes at 230 to 300 volts at a speed of 650 r.p.m. For charging the batteries there are two motor-driven boosters by Mavor and Coulson; the motors are shunt-wound and take current at 500 to 600 volts, and the boosters give 225 amperes at 20 to 160 volts, running at 850 r.p.m. They are separately excited at 350 volts. The *feeders* are triple concentric lead-covered cables, laid in iron, earthenware, or wood troughs filled in with insulating composition. All the feeders have conductors 1, 1 and 0·3 square-inch section, except four with sizes of 0·5, 0·5 and 0·25 square inch. They are tested to a pressure of 30,000 volts. Distributors of 0·25 square-inch section are laid in the main thoroughfares, and elsewhere are of 0·15 square-inch section. They are of the same type as the feeders. The contract for all the cables was equally divided between the British Insulated Wire Company and Callender's Construction Company. The station is equipped with 335 Tudor accumulators arranged in two batteries; with 25 pairs of regulating cells in each. The capacity is 1,100 ampere-hours at 150 amperes; the maximum discharge rate is 250 amperes. The cell boxes consist of sheet lead contained in a crate of cast lead; they are supported on steel girders covered with sheet lead, and are insulated by glass slabs standing on oil insulators. The regulating contacts are arranged along a girder fixed to the wall of the battery-room, contact being made by a trolley carriage running along the girder, and moved by a wire rope passing round drums which are geared to hand-wheels near the switchboard.

The switch gear is distributed on two sets of panels; the dynamo panels being on the engine-room floor and the feeder panels on a gallery above, the bus-bars running between the two. Each dynamo is provided with a separate positive and negative panel. The feeder panels are divided into sets supplying eight pairs of feeders and arranged in two rows one behind the other.

On the other side of the river, at a distance of nearly two miles, has been erected a second station, the Pollokshaws Road Works. Its equipment is very similar to that of the Port Dundas station, but as yet there are no accumulators; it is proposed, however, to remove two 200-volt Tudor batteries, now in sub-stations, and to erect them in the station, making them up to 250-volt batteries. The *boiler-room* contains four Babcock and Wilcox boilers of 1,100 h.p. each. The *engine-room* contains one 1,100-h.p. Willans-Crompton set, two 400-h.p. Belliss-Crompton sets, and two 200-h.p. Alley and McLellan-Mavor and Coulson sets.

The details of the supply during the year ending May 31, 1900, are as follows: Number of consumers, 2,852; number of public arc lamps, 265; maximum load, 4,258 kw.; units sold, 4,250,669; units generated, 5,226,818. The public arc lamps are connected in series of ten on the 500-volt outers.

The drawings in the article are: Map of feeders, views of engine-room, boiler-house and condensers, switchboards and battery-room; plans and elevation of both stations, the Belliss sets, the feeder panels, and street feeder and distributor boxes. G. H. B.

273. *Liverpool Power Stations.* (Electrician, 45. pp. 953–955, Oct. 19, 1900.)—Two new power stations have been erected by the Corporation at Pumpfields and Lister Drive for the purpose of supplying energy for lighting and tramways. The stations are about 2½ miles apart, the line joining them passing through the middle of Liverpool. The arrangements at the two stations are practically similar. In each the plant is divided into four independent sections, consisting of seven boilers and economiser, and three steam dynamos and accessories. The *engine-rooms* are 247 feet long and 50 feet wide, with *boiler-houses* 53 feet wide on each side. The boilers are of the Lancashire type, 30 feet by 8 feet, with flues 3 ft. 2 in. diameter, five Galloway tubes being placed in the flues. They are fired by Vicars stokers. At Lister Drive the coal is delivered from the railway siding into a wrought-iron storage tank over the stokers; at Pumpfields it is delivered from the canal into a similar storage chamber by means of belt conveyers. The engines are by Willans, three-crank, and triple expansion, having a continuous output of 1,200 i.h.p. at 230 r.p.m. The cylinders are 15 inches, 20½ inches, and 34⅝ inches in diameter, stroke 16⅞ inches; diameter of crank-shaft, 11 inches. The dynamos are by Siemens; they are multipolar and shunt-wound, with output of 1,420 amperes at 550 volts; the commutator consists of 560 sections, and is 57 inches in diameter. At Pumpfields, Körting ejector condensers are installed, there being one condenser for each engine, which requires 55,000 gallons of water per hour; the water is raised from the canal by centrifugal pumps to overhead tanks, each pump delivering 4,000 gallons per minute against a head of 50 feet. The pumps run at 365 revolutions, and have suction and discharge branches of 16 inches diameter, being steam driven. At Lister Drive there are Klein jet condensers, worked in connection with chimney coolers, the arrangements being described in some detail. It is impossible for any condensing water to enter the steam cylinders of the main engines, the exhaust steam main being carried to a height of 34 feet above the injection water-level, and arrangements are made for drawing off any water which may condense in this main below the barometric height. Each station has a battery-room with accommodation for 240 cells capable of giving an output of 200 amperes for one hour, or 80 amperes for four hours. There are also two switchboards, one for lighting and one for tramway purposes, separate dynamos being in general used for each. The coal elevators, ash elevators, mechanical stokers, and economiser scrapers are worked by motors varying from 2 h.p. to 12 h.p. These stations of course supplement those already existing, which had a capacity of about 10,000 h.p. A drawing is given showing the ground plan of the generating station at Lister Drive. W. H. S.

274. *Rochdale Electricity Works.* (Electrician, 45. pp. 955–957, Oct. 19, 1900.)—Current is supplied on the three-wire system at a pressure of 440 volts between the outers. The boilers are of the Lancashire type, 30 feet by 8 feet, working at a pressure of 150 lbs. The economiser contains 256 tubes; and

the chimney is 150 feet high by 6 ft. 6 in. diameter. The feed pumps are of the three-throw type, geared to motors; each is capable of delivering 2,000 gallons per hour into the boilers. The motors are enclosed, each having two commutators for series-parallel running, and were constructed by Wilson Hartnell. There are two cast-iron storage tanks, one of 3,000 gallons capacity for cold water and the other of 2,500 gallons capacity for the hot well. The engine-room contains two Belliss engines, direct coupled to Siemens two-pole dynamos, having an output of 180 kw., as shunt machines; but a series coil has been provided so that the machines can also be used as compound-wound for tramway purposes. The steam is condensed in a surface condenser, capable of dealing with 12,000 lbs. of steam per hour. The engine-room has a 10-ton travelling crane with a span of 33 feet, and lift of 20 feet. The battery-room contains 252 cells, capable of giving a discharge of 60 amperes for ten hours, or 250 amperes for one hour. W. H. S.

275. *Bury St. Edmunds Electricity Works.* (Elect. Engin. 26. pp. 618–627, Nov. 2, 1900.)—A direct-current supply is given, the distribution being effected on the three-wire system. The *boiler-house* contains two Lancashire boilers, 28 feet by 7 feet, working at a pressure of 150 lbs. per square inch. There is an economiser of 96 tubes, and in addition a Chevalet heater-detartariser, used for the purpose of heating and softening the feed-water. This latter is capable of heating 540 gallons of water per hour to 212° F. There are two feed pumps, one electrically driven, capable of delivering 1,000 gallons per hour, and the other steam driven, capable of delivering 2,500 gallons per hour. The *engine-room* is 25 feet broad and 35 feet long. It contains two steam dynamos of 60 kw. capacity each, giving 130 amperes at 460 volts and 500 r.p.m. The battery-room is 32 feet long by 92 feet broad, and contains 252 cells, giving a discharge of 500 ampere-hours when discharged for ten hours. The mains are triple concentric, and armoured. Two feeders are laid, having a sectional area of 0·2 square inch in their outer conductors; and a third feeder has an area of 0·1 square inch. The distributors have a sectional area of 0·125 square inch. Several drawings are given, showing the design of the station and the switchboard connections. W. H. S.

276. *City and South London Electric Railway.* (Engineer, 90. pp. 346–349, Oct. 5, 1900.)—The extension of the City and South London Railway to Clapham Common and Moorgate Street, and the further and later extension to the "Angel" at Islington, necessitated so considerable an increase in the generating plant that it was decided to discard the old station and system of working and put down a new installation. The present article describes this new station erected at Stockwell on a site adjoining the original one.

The system adopted is the continuous-current three-wire system with balancers, at a pressure of 1,000 volts on the outers. The running rails form the middle wire, and in each tunnel the working conductor forms one outer. Each working conductor is fed at three points—Stockwell, Kennington, and London Bridge. The Kennington feeder is coupled through a booster to compensate for the drop in the feeder. At London Bridge is a battery sub-station, fed from the main board at Stockwell on the five-wire system, a motor generator maintaining a high tension feeder 500 volts above the bus-bars; the pressure is reduced to the normal at the substation. At Moorgate Street, the "Elephant and Castle," and Clapham Common, balancers are placed, each capable of dealing with a load of 160–200 amperes concentrated on one side of the system,

In the generating station the *boiler-house* contains nine Davey Paxman "Economic" boilers, 15 ft. 6 in. by 8 ft. 9 in. diameter, capable of evaporating 8,000 lbs. of water per hour each, at a pressure of 160 lbs per square inch. Over the boilers the coal is stored on a steel and concrete floor in wrought-iron bunkers of about 1,000 tons capacity. The coal is delivered to a hopper outside the boiler-house, and thence it is elevated and conveyed to the bunkers by an elevating and conveying plant erected by the New Conveyer Company of Birmingham. From the bunkers the coal is delivered by measuring shoots to the hoppers of the Vicars mechanical stokers with which the boilers are fitted. The main steam range is duplicated, and consists of lap-welded steel pipes with solid flanges, and is so arranged that no expansion joints are needed.

The *engine-room* contains two 800-kw. sets, two 300-kw. and two 125-kw., all direct-coupled. The engines of the 800-kw. sets are slow-speed Corliss compound engines by Cole, Marchent, and Morley; working at 150 lbs. per square inch pressure, they indicate 960 h.p. when running at 85 r.p.m. and condensing. The cylinders are 24-inch and 49-inch by 4-feet stroke; they are not steam-jacketed, nor is there any steam-jacketed intermediate receiver. The governor controls the expansion on both cylinders. The fly-wheel is 24 feet in diameter, and weighs 40 tons; it is constructed with solid steel plates on either side. The crank-shaft deflects about $\frac{1}{1000}$ inch in 2 feet, and to cover this the bearings are allowed to swivel a slight amount. Throwing on and off the full load of 800 kw. produces no appreciable variation in speed of the engine.

The guaranteed steam consumption is 16·3 lbs. per b.h.p. hour; from the makers' tests it came out just under 15 lbs. The 800-kw. generators coupled to these engines are by the Electric Construction Corporation. The field-magnet yoke, carrying fourteen steel poles, is divided on the vertical centre line, and provided with gear for separating the two halves. The armature spider is bolted directly to the flywheel centre, so as to preserve the shaft and keys from strains due to sudden fluctuations of load. The other generating sets are, with the exception of one 125-kw. Willans-Siemens set taken from the old station, also by the Electric Construction Corporation, but are coupled to high-speed Willans engines. The 300 and 125-kw. generators have respectively six and four poles, and commercial efficiencies of 93 per cent. and 92 per cent. The larger sets can run for four hours, giving 400 kw. without injury.

The condensing plant and cooling towers are arranged for a maximum of 52,000 lbs. of steam per hour. The condenser has a surface of 5,500 square feet, and is provided with two steam air-pumps. The water is cooled in three cooling towers by an induced draught; two towers were supplied by Klein & Co., and the third formed part of the old station. The water is circulated by a steam-driven and by a motor-driven pump.

At the London Bridge substation two reducing sets by the Electric Construction Corporation take current from the feeders at an extreme pressure of 2,000 volts, and deliver at 500 volts on each side of the three-wire system, automatically compensating for the pressure drop in the feeders. Their rated capacity is 300 kw. continuously, or 400 kw. for two hours. At full, half, and quarter loads the efficiencies of the reducers are respectively 95½ per cent., 92½ per cent., and 89 per cent., while including the feeder loss they are 88 per cent., 89 per cents., and 87 per cent. There is also a battery of 556 No. 49 H.B. 11 type Tudor accumulators of 450 ampere-hours' capacity, discharging at 150 amperes, or 350 ampere-hours at 350 amperes; boosters are provided for charging.

The contract for the complete electrical equipment was let to the Electric Construction Corporation, with, as sub-contractors, Willans and Robinson, Cole, Marchent, and Morley, the Tudor Accumulator Company, and Callender's Cable Company. The condensing plant was erected by Cole, Marchent, and Morley, the boilers by Davey, Paxman & Co., and the coal-handling plant by the New Conveyer Company.

The drawings include plan and section of the station, plan and elevation of the Corliss engine, and side and end views of the 800-kw. generator, with two photographic views of the large generating set. G. H. B.

277. *Blackpool and Fleetwood Tramway.* **T. G. Lumb.** (Elect. Engin. 26. pp. 199–201, Aug. 10, 1900. From the Transactions of the Royal Institution of Public Health.)—This line, 8½ miles long, is one of the best-paying lines in the world. In its first twelve weeks it carried 550,000 passengers with only ten open cars. In Blackpool and Fleetwood the lines are laid as a tramway paved with granite setts. Between the two towns light railway construction is used, and the line is fenced in and passes through several cuttings. There are ten level crossings, all provided with cattle guards. On the tramway section ordinary girder rails are used, weighing 83–98 lbs. per yard, and bonded with two Daniel bonds. On the light-railway section 56-lb. Vignoles rails are spiked to creosoted redwood sleepers embedded in 12 inches of ballast. Round curves, fangbolts and clips fix the rails. Plastic rail bonds are used consisting of plastic metal in a cork case, which is clamped up between rail and fish-plate.

The generating station is 2 miles from Blackpool and ¼ mile from the line. Alongside is a car-shed 170 feet by 67 feet, holding twenty-four cars. The plant comprises four Galloway Lancashire boilers, 30 feet by 8 feet diameter, built for 120 lbs. per square inch. Water is drawn from a reservoir, close to engine-room, fed by surface springs, or alternatively from the public supply through a storage tank. A Klein cooling tower is used. The feed-water is heated by a Green's economiser with 288 tubes. The steam main is a ring, and both it and the branches to each engine are provided with steam separators. The steam and exhaust-pipes are in a basement under the engine-room. The engine-room contains five Mather and Platt open marine-type vertical compound engines with cylinders 12 inches and 24 inches by 16 inches stroke, each giving 200 h.p. at 175 r.p.m.; these are direct-coupled to six-pole dynamos, giving 120 kw. at 505 volts. Ledward ejector condensers are used, and take their water from the storage tank. After leaving the condensers the water is cooled by passing down a wooden trough and some distance round the reservoir before entering it. Steam-driven centrifugal pumps circulate the water. The dynamos are shunt-wound, and are peculiar in having a collar connecting the field coils and encircling the armature; this arrangement effectually prevents all sparking. The efficiency of the machines is 93 per cent. Three 26-kw. boosters are provided, each consisting of a motor connected to the bus-bars, direct-coupled to a generator giving 130 amperes at 200 volts. By means of suitable switches any feeder may be connected to a booster, and thereby the pressure at its feeding-point kept constant. This allows all the dynamos to be run in parallel at the same voltage, and all the feeders to be of the same size. The boosters are also used in charging the accumulators independently of the line. The feeders are $\frac{3}{4}$ lead-covered and armoured cables laid in trenches alongside the track. One feeder runs direct to an accumulator station near the Fleetwood terminus, where there are 250 300-ampere-hour chloride cells. The principal function of the battery is as a

regulator, but it is also used to operate the cars early and late. Double trolley wire, 0·348 inch diameter, is used throughout, fixed to brass ears insulated from the pole arms with Etna insulators. In Blackpool the suspension is by bracket side-arms, except where the width of the road necessitates span wires; elsewhere centre poles with double bracket-arms are employed. The Company now has twelve open and twelve closed cars, and three trailers, with twelve more on order. Each motor-car is 34 ft. 5 in. long, is mounted on two bogie trucks with 28-inch wheels, seats 48 passengers, and weighs 12 tons loaded. Each bogie carries a G. E.-1,000 motor, rated at 35 h.p., and driving through 4 : 1 single-reduction gear. There are no outside seats. E. H. C.-H.

278. *Perugia Electric Light and Traction System.* (Elettricità, Milan, 19. pp. 561–566, Sept. 8, 1900.)—*System:* Continuous current, three-wire, at 220 + 220 volts, with batteries. The *boiler-room* contains three water-tube boilers by Tosi, working at a pressure of 10 atmospheres; their dimensions are: Heating surface, 167 sq. m.; number of tubes, 81; size of tubes, 102 × 5,500 mm.; size of boiler, 7,430 × 1,400 mm. diameter. The feed-water is treated with sodium carbonate in a purifier. The boilers are fired by hand. The *engine-room* contains three vertical compound tandem engines by Tosi; two are for lighting, and give 170 b.h.p. at 9 atmospheres pressure and 200 r.p.m. The cylinder diameters are 375 and 600 mm., with a stroke of 425 mm. The third is for traction, and is of the same type, with cylinders 300 and 475 mm. and a stroke of 350 mm.; it gives 120 b.h.p. at 250 r.p.m. The condensers are sufficient for 6,000 kg. of steam per hour, and have a cooling tower by Balke & Co.

The two lighting engines drive directly two Siemens and Halske dynamos, type T. $\frac{7}{3}\frac{6}{T}$, giving 135 to 110 kw. at 500 to 440 volts. The engine for traction drives a similar dynamo, giving 100 kw. at 500 to 550 volts. Two Siemens and Halske motors, type U.A. $\frac{1}{2}\frac{8}{6}$, of 38 h.p., each running at 650 to 720 r.p.m. at 220 to 245 volts, drive two dynamos serving as boosters and balancers; the latter give together 50 kw. at a pressure of from 40 to 200 volts. The station is equipped with a battery of 264 Tudor elements of a capacity of 756 ampere-hours for three hours, or 1,015 ampere-hours for ten hours; this battery is for lighting. Another battery for traction has 256 Tudor cells with a capacity of 165 ampere-hours for one hour.

All the feeders and distributors are overhead bare copper wires supported on poles or brackets. There are seven feeders, one of 120 sq. mm. section, three of 70, and three of 50. For public lighting there are forty-four 8-ampere arc lamps run nine in series on 440 volts or four on 220 volts, and about 100 incandescent lamps of 16 and 32 c.p.

The tramway track, 5,100 m. in length, is equipped on the trolley system, with two Siemens collectors on each car. The trolley wire, 8 mm. in diameter, is carried on span wires between the houses. The rails are of Phœnix type, weighing 42·8 kg. per metre, and 150 mm. high. They are tied together at a gauge of 1 m. by flat iron ties 1·8 m. apart. The joints are bonded by bonds 8 mm. in diameter of the Chicago type. There are three motor-cars, two passenger trailers, and two goods trailers. The motor-cars are equipped with two Siemens motors of 25 to 30 h.p. each, and have a capacity of twenty-four passengers, while the trailers can take thirty. The maximum speed is 25 km. per hour. No drawings accompany the article. G. H. B.

279. *Electric Traction in Kansas City.* (Street Rly. Journ. 16. pp. 741–760, Oct., 1900.)—On account of very heavy grades there were 63 miles of

track in Kansas City operated by cable; all these lines have been converted to electric traction except those in two streets, where the grades reach 18·5 per cent. The total length of track of the chief company is 160 miles. All track is laid with centre-bearing rails with the ball of the rail above the street level, in order to comply with City Ordinances. All recent rails are 103-lb. centre-bearing girder rails in 60-feet lengths. No ties are used in streets which are asphalted from kerb to kerb, reliance being placed on the non-movable character of this paving. Falk cast-welded joints have been found very satisfactory on 6-inch and 9-inch rails, but on 4½-inch rails there have been many breakages at welded joints.

The cars have gates, and no one can enter or leave without the motor-man opening them. On a suburban line an electric locomotive is used for coal haulage and construction work. Its controllers are said to be the only ones which will successfully operate four motors in series, series-parallel, or all in parallel without the use of any auxiliary commutating switch, and with one revolution of the handle. Power for almost all the lines is supplied from a station on the Kaw River containing 7,000 h.p. in engine capacity. A new large unit consists of a 2,500-h.p. Allis-Corliss engine direct-coupled to a 1,600-kw. G.E. generator with a 40 per cent. overload capacity for three hours. The engine exhausts into an independent Wheeler condenser having 5,000 square feet of cooling surface; its shaft is of hollow-forged, fluid-compressed steel; its flywheel is 24 feet in diameter and weighs 160,000 lbs.

The cable cars are driven from a station where a 300-kw. compound-wound motor operates 24,000 feet of cable carrying sixteen trains on a line having one 10 per cent. grade. The ordinary motor input is 200–600 amperes, running up to 800 amperes on heavy days. The cable on the steepest route has to be renewed every forty days, and is then transferred to lighter routes, where it lasts about six or nine months. The cables run at 12 miles per hour.

The Kaw River station is amongst the most economical in the world. For the first seven months of 1900 the average total cost of power, exclusive of interest, taxes, and insurance, was $·0041 per kw. hour, the cost of coal being about $1·20 per ton. The load was usually taken by two 1,200-kw. units, with a 550-kw. set to take the "owl-car" load. Eleven men are required to run the plant during the twenty-four hours. For another station on the Blue River the corresponding figure for the same period was $·0079, or nearly double the Kaw River figure. The difference in fuel consumption per kw.-hour is almost as great. Both stations are well equipped and modern, are owned by the same company, and operated in the same manner. The differences in equipment are: Large as against small direct-connected units, compound-condensing as against simple-condensing engines, water-tube as against tubular horizontal boilers, and mechanical as against manual stoking. The comparison is a strong argument in favour of replacing small stations by one large station with large units.

An interurban line runs out 26 miles from Kansas City to Leavenworth almost entirely on its own right-of-way. The track and wheels are of standard steam railway form, permitting very high speeds. Spring switches are used at turnouts in order to enable cars to run through them at high speed. The trolley wire is 8-shaped. The feeders are of bare aluminium of 362,000 circ. mils. section. There are four competing steam railroads. There are ten electric cars, 41 feet long by 9 feet wide overall, weighing 22 tons each. They carry four steel 50-h.p. motors each, geared to give 45 miles per hour, and one controller. The Magann storage air-brake system is used with success in spite of the length of run between charges, which are only taken

at the power station midway, where an Ingersoll-Sergeant compressor gives 300 lbs. per square inch. The storage tanks hold enough charge for 100 miles' run. The pressure is brought down between the tank and the brake cylinder to 45 lbs. per square inch by a reducing valve. E. H. C.-H.

280. *Rotary-Transformer Stations at Buffalo.* **R. E. Danforth.** (Street Rly. Journ. 16. pp. 893–895, Oct., 1900. Paper read before New York State Street Railway Association, Sept., 1900.)—An account is given of the scheme referred to in Abstract No. 389 (1900.) The rotary converters are six-pole machines and run at 500 r.p.m. They are fitted with magnetic oscillators which give the shaft an endwise pull at regular intervals of a few seconds, thus preventing the brushes from wearing tracks. The windings of converters above 500 kw. are connected to the step-down transformers as six-phase instead of three-phase in order to increase the efficiency by reducing the losses in the armature winding. The connection of the armature winding to the collector-rings serves incidentally the same purpose as the equaliser-rings used on parallel-wound generators, equalising the field strength under all poles and improving commutation. A description of the switch gear and of the methods of starting up the converters is given. Each of the four substations has one attendant. E. K. S.

281. *The Engins Electric Power Station.* **J. L. Routin.** (Ecl. Électr. 25. pp. 24–45, Oct. 6, 1900.)—A full description of the power plant for a large electric transmission near Grenoble, with 15,000 volts on the line. The power station is on the Furon, which feeds the Isere River, the height of the fall utilised being 282 m. The three-phase alternators are of the Labour type, and give 350 kw. at 125 volts, which is raised by three-limb step-up transformers to 15,000 volts. The electrical plant has been mostly supplied by the Société l'Eclairage Electrique of Paris and G. Grammont of Pont-de-Chérui. Illustrations show the high-tension line where it crosses the Isere in a very long span ; also the railway line where a special steel bridge has been provided. Very complete particulars of tests for efficiency, &c., are given at the end of the article. E. K. S.

282. *Buenos Ayres Lighting and Tramway Station.* (Elect. Rev. 47. pp. 61–65, July 13 ; 95–96, July 20 ; 239–240, Aug. 10 ; and 265–266, Aug. 17, 1900.) —*System :* Single-phase alternating-current at 3,400 volts with transformer substations supplying a three-wire network with 230 volts on the outers for lighting, three-phase current for power, and continuous current for traction. The *boiler-room* contains eight Belleville water-tube boilers, each with 10 sets of 12 tubes, inclined at an angle of $2\frac{1}{2}°$. The heating surface of each boiler is 106 sq. m., and the output 3,750 kg. of steam per hour. Steam is discharged downwards from nozzles in a pipe fixed 12 inches above the fire-bars, with a view to mixing the furnace gases. The feed-water is heated by an economiser placed above each boiler. The boiler working pressure is 225 lbs. per square inch. The steam is taken by a ring main to a group of reducing valves, one for each engine, and the pressure can by these be regulated by hand within a range of 40 to 130 lbs. per square inch. The *engine-room* contains four 500-kw. Allis-Corliss horizontal compound engines, and two Gritzner vertical engines, with piston valves, driving exciters. The main engines have cylinders 20-inch. and 40-inch. with 36-inch. stroke, and run at 125 r.p.m. They have a flywheel 12 feet in diameter weighing $17\frac{1}{2}$ tons. The cut-off is regulated by a Reynolds governor. The exciter engines have cylinders 225 and 340 mm. with stroke

of 240 mm. and run at 325 r.p.m. In an adjoining temporary engine-room for traction generators are one McIntosh and Seymour 500-kw. vertical triple-expansion three-crank engine with gridiron valves controlled by a flywheel governor, and two of the same makers' compound tandem engines with piston valves. The cylinders of the former engine are 14, 23, and 40-inch, with 36-inch stroke ; the speed is 125 r.p.m. Those of the latter engines are 11 and 19-inch, with 23-inch stroke ; the speed is 230 r.p.m. Each engine is connected to an independent Wheeler surface condenser of 1,000-h.p. capacity. Each of the Allis-Corliss engines drives between its cranks a 500-kw. 3,400-volt monocyclic alternator of the revolving field type. The alternator has a principal single-phase winding with a supplementary power winding of about one-quarter the capacity connected with the principal winding at its central point and giving three-phase current. The field-coils are 48 in number. The Gritzner engines drive directly two multipolar compound-wound exciters, giving 30 kw. at 130 volts. Another similar exciter is driven by a 50-h.p. 8-pole three-phase motor through a flexible coupling at a speed of 750 r.p.m., the motor taking current from transformers at 230 volts. In the temporary station the tramway generators are—one multipolar direct-driven 500 kw. 500-volt dynamo and two similar ones of 225 and 100 kw. To the last can be belted a 100-kw. monocyclic alternator of the revolving armature type, arranged to run as a motor or as a generator. A storage battery is to be installed as a reserve for excitation. The primary and secondary *feeders* are triple-cored, lead-sheathed and armoured cables, laid in trenches under the pavement, on a layer of sand ; they are covered by a second layer of sand and bricks ; at street-crossings they are laid in iron pipes. Seven inter-connected feeders go to the principal substations, and from these primary cables distribute to other substations. The heaviest feeder has two cores of 170 sq. mm. and one of 60 sq. mm. ; the heaviest primary cable has two cores of 50 sq. mm. and one of 16 sq. mm. ; the heaviest secondary cable has three cores of 95 sq. mm. There are 50 transformer substations, each for four 30-kw. transformers. Boosting transformers enable the pressure at each feeding-point to be regulated. The cables are by Felten and Guilleaume. For supplying polyphase motors additional cables are run from the nearest substation. Fifteen-ampere street arc lamps, to the number of 350, are run off small transformers with ratio 230/33. There are at present installed 50,000 16-c.p. lamps and 300 h.p. in induction motors. The price charged for lighting is 25 cents per unit with discounts on a sliding scale from 5 per cent. for a monthly consumption of over 25 units to 20 per cent. for 200 units, and an additional discount depending on the average annual time of burning per lamp, varying from 5 per cent. for 500 hours to 20 per cent. for 2,000 hours. The price for power is 12½ cents per unit. The tramway lines operated electrically include 13 miles of double track and 5 miles still under construction. The system is overhead trolley. The rails are 6⅜ inches high, and weigh 86 lbs. per yard. For a certain length their joints are cast-welded on the Falk system, with Chicago bonds round the welds ; the rest of the track is bonded with Edison-Brown plastic bonds and one Chicago bond. The track is laid on three systems : in the streets, with wood pavement, it is laid on a concrete base the width of the track ; towards the outskirts, where the paving is composed of granite setts, on longitudinal concrete sleepers ; and in the suburbs, where there are macadamised roads, on native hard-wood sleepers on a foundation of broken stone. Feeders and distributors are laid underground, and are paper-insulated lead-sheathed cables by the British Insulated Wire Company, drawn into Doulton stoneware conduits. At feeding-points are placed pillars

containing switch, fuse, lightning arrester and telephone to station. The drop of voltage is kept within Board of Trade limits by two negative boosters driven by shunt-wound motors. The overhead line is carried, according to circumstances, on span-wires between houses or between poles, on centre poles with double arms, or on side poles with single arms. The trolley wire is No. 00. The cars, ninety-six in number, are of various types, double-truck double-deckers with top roof, combination open and closed cars, and open cars with reversible transverse seats. The trucks are of the Peckham extension pattern. Each car has two G.E.-1,000 motors, and is fitted with series-parallel controllers and electric brakes. G. H. B.

283. *Indiana Electric Tramways.* (Street Rly. Rev. 10. pp. 424–432, Aug., 1900.)—The tramway system of the Indiana Railways Company consists of 42 miles of track, almost the whole of which is single, and serves a population of about 70,000. The track is laid with T-rails weighing 70 lbs. per yard, $4\frac{1}{8}$ inches high in the country, 7 inches high in paved streets, and either 30 feet or 60 feet in length. The rails are laid on oak ties, and are bonded with No. 0000 Washburn and Moen bonds, single bonds being used with low rails and double with 7-inch rails. In paved streets the foundation consists of gravel 6 inches deep, on which the ties are laid at intervals of 2 feet, the spaces being filled with concrete. Wooden poles are used except in main streets, with span wires almost throughout. It is intended eventually to utilise water-power, but at present there are three steam-power stations. The South Bend station contains five tubular boilers, one feed-water heater, two Buckeye simple non-condensing engines with cylinders $26\frac{1}{2}$ inches diameter and 36-inch stroke, running at 125 r.p.m., and two 250-kw. Westinghouse generators driven by belt. The steam pressure is 100 lbs. per square inch ; the feed-water contains lime and magnesia, and sodium triphosphate is used to soften it. There is also a 3,000-light Westinghouse steam-alternator for lighting service. At Osceola there are three tubular boilers working at 100 lbs., one feed-water heater, two 22-inch × 33-inch simple non-condensing Buckeye engines belted to a 200-kw. General Electric and a 250-kw. Westinghouse generator. Wurts tank lightning arresters are used. At Dunlap there are three tubular boilers, and one simple Allis engine driving three generators at 900 r.p.m. by belt. The total daily consumption of fuel averages about 17 tons of coal, costing 11s. per ton. There are several overhead feeders, tapped into the trolley line at intervals of 1,000–1,500 feet. The cars number 31 open and 21 closed on single trucks, 10 interurban double-truck cars, and 8 open trailers. The interurban cars measure 42 feet overall, and are equipped with four 49A Westinghouse motors and McGuire trucks ; they carry 44 passengers each. The smaller motor-cars are of similar type, with two motors each. Full details of the system of accounts and report forms used by the company are given in the article. A. H. A.

284. *Street Railways in Portland, Me.* **C. B. Fairchild.** (Street Rly. Rev. 10. pp. 485–494, Sept., 1900.)—The city of Portland has 46 miles of track owned by the Portland Railroad Company, as well as an interurban line running 14 miles out to Yarmouth. A new power house to operate all the city lines is situated on tide water, and contains a 1,500-h.p. vertical-compound engine coupled direct to a 1,050-kw. G.E. generator. The engine has cylinders 26 and 50 × 42 inches, and runs at 100 r.p.m. with 120 lbs. steam pressure. The throttle is controlled from three positions by means of hand-wheels—one on the floor and one on each platform. The valve gear is of the Rice and Sargent type,

and has silent vacuum dash-pots. The flywheel weighs about 85,000 lbs., and the diameter of the main shaft at the armature is 22 inches. All the valves have double ports, and the exhaust valves are set nearer to the piston than the steam valves, so that the clearance is largely reduced. The valves are operated by direct motion from the eccentrics without the medium of wrist plates. There are two eccentrics, one for the inlet valves and one for the exhaust, on each cylinder. The range of cut-off is from zero to $\frac{3}{4}$-stroke, which gives the engine great capacity for overloads and ensures perfect regulation under any condition of load. The cut-off latches operate without springs, dropping by their own weight, and are so constructed that the pressure from the eccentrics is on a line below the pivotal point, so that the latch cannot jump up. The wearing-contact plates on the latches are square, and are made of hardened steel, so that by shifting a plate and turning it over there are eight corners for wear. The point of cut-off is determined by a rod from the governor which actuates a yoke behind the latch, operating by means of rollers on a curved lever also attached to the cut-off. In connection with the governor is a safety device, designed to cut off the steam in case the governor belt should break or fail to work properly. The connecting rod is so designed that by removing one bolt it can be detached from the crank-pin, and being swung to one side the engine can be run by one cylinder if required. When it is found necessary to remove the connecting rod it can be swung out sideways through an opening in the frame. The flywheel is built in eight sections, each section consisting of a piece of the rim and an arm. E. H. C.-H.

285. *Quebec Tramways.* **D. E. Blair.** (Canad. Elect. News, 10. pp. 179–182, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—The gradients and curves on the City of Quebec tramway lines are exceptionally severe ; the gradients reach 15 per cent. in places, and numerous curves have radii as low as 35 to 40 feet. The speed on down-grades is limited to 4 miles per hour—a precaution which has resulted in an almost complete immunity from accidents. The average speed is 8 miles per hour. Hand-brakes with 100 : 1 leverage are exclusively used ; the brake shoes, weighing 19½ lbs., last 6,150 miles. The car wheels are of chilled cast iron ; of those removed during the first three years' working, 75 per cent. were worn out, 18½ per cent. had flats, and 6½ per cent. had flanges broken. The expenses incurred in clearing away snow are very heavy, amounting to $1·54 per car-day on an average throughout the year.

During the four winter months it requires 5·1 kw. to heat each car, and during November and April half that amount.

This electric railway, as well as all the lights and motors in Quebec, is operated through a substation within the city, the power being derived from the Falls of Montmorency. The power house contains three 600-kw. and one 750-kw. two-phase, 66 cycle 5,500-volt alternators ; one 600-kw. double-current 273–500-volt Westinghouse generator, besides exciters, &c. The power is transmitted to the city over 16 wires, carried on two separate pole lines. The substation contains two 600-kw. two-phase synchronous 5,000-volt motors, direct-coupled to two 500-kw. 550-volt G.E. railway generators. There are also two 200-kw. synchronous motors for driving four Brush arc lighters.

The paper concludes with particulars of an electric railway, 21 miles long, between Quebec and the Shrine of St. Anne de Beaupré. E. K. S.

286. *Electric Transmission Plants at Moodie's, De Kaap Goldfields, Transvaal.* **H. J. S. Heather.** (Inst. Civ. Engin., Proc. 141. pp. 269–306, Aug., 1900.)—The author describes his four years' experience in the management of a power transmission plant in the mountainous district of Lydenburg, South Africa. The motive power was water, and all the turbines, regulating gear, pipes, &c., were supplied by the Pelton Water-Wheel Company of New York. The first electric plant was put down in 1894 by Messrs. Goolden & Co. Two separately excited continuous-current generators were supplied, which gave 1,500 volts at 500 r.p.m. They were connected in series, so that the pressure at the generating end of the line was 3,000 volts. The current was conveyed a distance of 23,700 feet by means of overhead wires to a substation, where it actuated two motor generators, the motor armatures of which were in series and the generator armatures in parallel at a pressure of 625 volts. At the low-pressure switchboard it was divided into five separate circuits and distributed to the various mines. It was found that two 11-h.p. motors were barely sufficient to work a ten-stamp mill, each stamp weighing 950 lbs. with an 8-inch drop and making 92 blows per minute, together with four Scoular concentrating tables and a 15-inch Blake-Marsden stone-breaker. In order to avoid overloading, it was necessary to hang up one of the stamps. The weak points of this 3,000-volt direct-current system were: (1) Its low efficiency (only 51·5 per cent. reckoning from the generator terminals, (2) the cost of the upkeep of the substation, (3) the impossibility of running the plant during the frequent tropical thunderstorms, and (4) the uncertainty of the telephone service, which was a necessary adjunct.

In 1895 Rennert and Lenz, of Johannesburg, replaced the direct current by a three-phase alternating plant. Four three-phase generators were provided, each capable of giving 100 kw. at 200 volts at a speed of 430 r.p.m. By means of transformers the pressure was raised to 10,000 volts, which was the pressure adopted for transmission. The transformers at each end were star wound, the neutral points being insulated from both frames and earth. Three 50- and two 30-h.p. motors were supplied at first, but, as they had short-circuited rotors, their operation at starting was unsatisfactory. In the latter type of motor, supplied by the Allgemeine Elektricitäts Gesellschaft of Berlin, a variable resistance was inserted in the rotor circuit at the start, and the motors worked satisfactorily. The regulation of the Pelton wheels was effected automatically by deflecting the nozzles, but after a time the sand and mud made the flexible joint so stiff that the regulating gear failed to act. In order to prevent the water-wheels racing an ingenious arrangement was devised to keep the load constant; when the load was taken off and the water-wheel consequently quickened, an artificial load was automatically introduced into the circuit. The first forms of lightning arresters used proved inefficient to protect the lines during the tropical thunderstorms. A form supplied by Siemens and Halske in 1897 proved effectual. It was very similar to the Thomson-Houston arrester, and, although simpler, worked on the same principle. In experimenting on these arresters by starting artificial arcs the author found that when one arced to earth it invariably caused the 10,000 volts to arc across the three-eighths inch air-space of a neighbouring arrester; the author can give no explanation of this. While putting up the lines workmen often got severe shocks four or five hours before thunder became audible. It was found that certain parts of the line were liable to electric discharges, and so arresters were fitted at these points. These parts of the line were not necessarily the highest, and there was no apparent cause for their liability. The telephone arresters were of the Post

Office pattern and worked satisfactorily, although on several occasions the violent discharges caused drops of molten metal to earth one or both wires. The author suggests the use of carbon instead of metal for lightning arresters. Comparing the new three-phase with the old direct-current system, the author sums up as follows: (1) The saleable output for a given quantity of water was increased 50 per cent. (2) The staff and other expenses were reduced 50 per cent. (3) It was possible to work during thunderstorms. (4) There was no need for a telephone service. (5) Three-phase generators and motors are less liable to breakdown. (6) The motor speeds remained constant.

A. R.

287. *Graz Electric Tramways.* **P. Poschenrieder.** (Zeitschr. Elektrotechn., Wien, 18. pp. 417–422, Aug. 26, and 429–435, Sept. 2, 1900.)—A detailed description is given of a tramway installation carried out by Siemens and Halske. Particulars of a fuel and steam-consumption test are given, and also a full list of the tramway staff and the duties of each member. The generating plant consists of three single-crank Corliss tandem-compound horizontal engines driving eight-pole dynamos. There is also a Laval steam turbine.

E. K. S.

288. *Lachine Rapids Power Station.* **C. T. Child.** (Elect. Rev. N.Y., 37. pp. 244–250, Sept. 12, 1900.)—The station has been erected to utilise the water-power of the Lachine Rapids in Montreal for lighting and power purposes.

A forebay 1,000 feet wide has been formed in the Rapids by the construction of a dam 4,000 feet long, consisting of crib-work ballasted with broken rock, filled with small material and covered with stone. The depth in the forebay is 13 feet. The fall in the Rapids of 20 to 25 feet per mile gives an available fall at the turbines of 16 feet. At the lower end of the forebay is built a solid masonry dam, on which the power house is situated. Here are erected 72 turbines of 300 h.p. each; they have vertical shafts and cylinder-gate wheels 54 inches in diameter. The wheels are set in flumes, the shafts ascending through the flumes, every six gearing into a common shaft actuating one dynamo. Two types of governors are used—the Giessler electro-mechanical governor and the Lombard governor; each controls the gates of a set of six turbines.

The generators are General Electric three-phase machines with revolving fields of 40 poles; each develops 750 kw. at 175 r.p.m.; their voltage is 4,400 on each phase. The exciters, also by the General Electric Company, are driven in pairs by an independently governed water-wheel; they give 75 kw. at 150 volts running at 660 r.p.m.; they are four-pole and compound-wound.

From a tower at one end of the power house a transmission line 32,000 feet long runs to the McCord substation, where two synchronous motors are installed, each driving two 125-light direct-current arc machines. The transmission line consists of twelve three-phase lines (36 wires in all), consisting of No. 0 copper wire mounted on triple-petticoat porcelain insulators carried by wooden cross-arms on steel poles. These poles are built up of four steel angle-irons riveted together with latticed strips between; they are 29 feet in height. The line crosses the Lachine canal in cables run in a conduit 33 feet below the water-level. The twelve lines are normally run in parallel; they supply the synchronous motors through three 150-kw. oil transformers

of ratio 4,000 : 2,000, with water-cooling pipes in the oil. There are also four 250-kw. transformers transforming to 2,300 volts, and three of 30 kw. each to 225 volts, the latter being used as boosters to the 150-kw. transformers. All the transformers are by the Wagner Electric Manufacturing Co. This sub-station supplies twenty 2,400-volt distributing circuits, one 4,000-volt circuit to the Imperial Electric Light and Power Station, and two to the plant of the Standard Electric Light and Power Company. The high-tension distributing system is laid underground and feeds the 110-volt overhead network through transformers carried on poles.

The present load is about 75,000 lamps and from 2,500 to 3,000 h.p. in motors. G. H. B.

289. *Alternate-Current Motors in a Textile Mill.* **A. F. M'Kissick.** (Amer. Electn. 12. pp. 513–515, Nov., 1900.)—In 1894 the Columbia Mills at Columbia, S.C., put down a water-power electric plant to drive a new mill of 68,000 spindles. The power house, 2½ miles from the mills, has wheel-pits and feeders for five pairs of horizontal wheels, each pair capable of giving 1,200 h.p. Three G.E. three-phase generators have been installed of the revolving armature type, giving 750 kw. at 3,600 volts and 60 cycles per second. The turbines are "Victors," with Giesler electro-mechanical governors. The generators, which feed the lines direct without transformers, are worked in parallel, all three machines being connected together before starting up, and the excitation raised as the speed rises; this method of paralleling is found easy and satisfactory. An old mill, formerly driven by a 450-h.p. engine, is now operated by ropes from a self-starting synchronous motor at 3,000 volts. The new mill contains 28 motors, also three 275-kw. and six 165-k.w. transformers, cooled by two 10-h.p. air-blast fans as well as a suction fan. The powers provided for the various operations are: One 50-h.p. motor for the cloth-room machinery and elevators; one ditto for aerophor pumps and heating apparatus; four 75-h.p. motors for picker-room machinery; four 130-h.p. motors for operating 1,580 looms; one 130-h.p. motor for operating 28 spinning-frames; three 130-h.p. motors and two 30-h.p. motors for operating carding-room machinery; nine 130-h.p. motors and four 50-h.p. motors for operating spinning-frames. The motors are attached to the ceilings. Owing to the amount of "lint" and "flyings" in the spinning and carding-rooms, it has been found necessary to use the squirrel-cage type of motor, which takes a very heavy starting current, but when once started runs satisfactorily. All the other motors are of the clutch type, with variable resistance in the rotor. In order to increase the power factor of the plant an over-excited synchronous 400-kw. motor has been installed, to run light and act as a rotary condenser. It is connected in parallel with the secondary 220-volt mains, and reduces the wattless currents, and therefore the temperatures, in the transformer-lines and the generators as well as the inductive drop. Without the condenser-motor the generator e.m.f. was 3,780 volts, the current output 435 amperes, and the power factor of the plant 0·86. With it, these figures respectively became 3,690, 402, and 0·94. It was found that more power was required in winter than in summer and in the early morning than at midday; consequently it is economical to keep the mills always well heated and dry. E. H. C.-H.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

290. *Guard Wires and Overhead Construction.* **S. Woodfield.** (Elect. Rev. 47. pp. 448–449, Sept. 21, 1900.)—On modern trolley standards a stop prevents the pole rising sufficiently to foul the overhead wires, but there is nothing to prevent its swinging round and fouling a suspension pole. The author suggests doubling the distance of guard wires above the trolley wire, in order to minimise the chances of the trolley pole fouling it, or of broken telephone wires coming into contact with the trolley wire. Shallow grooved ears with lugs at the ends are being gradually replaced by deep grooved ones without lugs; ears are now being made up to 42 inches for curves. "Pull-off" wires are being superseded by placing more poles round curves, with the long ears bent *in situ*. The G.E. Company of America are now using a grooved trolley wire of circular section, which has all the advantages of 8-shaped wire, without the disadvantage of readily making kinks which cause the trolley to jump. It is not good practice to make the top half of the bracket-hanger clamp serve the double purpose of supporting the hanger and guard-wire standard, for, if the trolley wire snapped, the whole bracket clamp would turn round, and might cause the guard wire to break or sag on to the trolley wire. Moreover, in straining up the guard wire, owing to the length of the leverage the bracket hangers themselves are pulled out of the vertical, thus causing a kink in the trolley wire. Where guard wire is used over very short distances, say between two or three poles, it should be earthed directly to the rails, otherwise, if it came into contact with the live wire the earth would not be good enough to knock out the station circuit-breakers, although sufficient current might be passing to make the guard wire red-hot and the ground round the pole dangerous. This has occurred more than once. Guard wires should be put up with a view to standing the same stresses as trolley wire. A convenient-sized wire to use is a 7/17 S.W.G. galvanised mild steel, breaking with a load of not less than 1,400 lbs., and an extension of 4 per cent. on 12 inches. A good test for galvanising consists in dipping a sample of the wire into a saturated solution of copper sulphate for one or two minutes, then drying it so that it is perfectly clean and repeating this process half a dozen times. If the galvanising is not perfect the iron will be dissolved and the copper precipitated in a spongy mass on the wire. After erection the guard wires should be rubbed down with vaseline, to protect the zinc against hydrochloric and sulphuric acids and sulphuretted hydrogen, traces of which are invariably present in towns. In place of guard wires a wooden strip supported by clips from the trolley wire itself has been used. The strip is made of canary wood, or preferably kauri pine, and the clips are placed at 3-feet centres, and soldered to the trolley wire. The strip should be thoroughly painted with P. and B. paint. Considerable trouble has arisen with the clips, owing to knocks from the trolley wheel causing them to come unsoldered. Where guard strip is employed a considerable factor of safety should be allowed in the trolley wire, as ice and snow may add enormously to the weight per unit length, and a far bigger surface is exposed to the wind. Guard wires have been practically abandoned in the States. The wires erected on the Buffalo-Niagara Falls transmission lines have been taken down, decreasing the number of short circuits, and with no bad results from lightning. Experience suggests the following points with regard to the erection of guard wires: (1) They

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

should be vertically over the trolley wire, and well anchored at frequent intervals. (2) They should not be used round curves where "pull-off" wires would be necessary, guard strip being far more suitable. (3) Stronger and more durable material should be employed, and greater care should be exercised in erection and examination. E. H. C.-H.

291. *Detector for Low Bearings.* **G. Bright.** (Elect. World and Engineer, 36. p. 188. Aug. 4, 1900.)—A large traction company, operating 300 cars, turned 50 cars into the repair shop between January 1 and April 15, 1900, on account of low bearings, which had allowed the armatures to rub on the lower pole-pieces, thereby destroying the insulation and damaging the teeth. One-third of these had to be entirely rewound. The author uses a detector to give warning of a low bearing before any damage is done. The device is simply a bent spring fixed to, but insulated from, the magnet casting. Before the armature can touch the pole-pieces its teeth will come into contact with the spring, thereby closing the circuit of a bank of lamps or other warning signal. E. H. C.-H.

292. *Wheel Flanges and Rail Grooves.* **W. G. Keagey.** (Tram. Rly. World, 9, pp. 362–364, Aug., 1900.)—The primary cause of the breaking of wheel flanges is the use of a girder rail with a narrow groove. The Manchester Corporation has recently secured official approval of an excellent rail section, having a tread 2 inches wide and a $1\frac{1}{8}$-inch groove. With the 1-inch groove previously allowed sharp curves were impossible with long wheel bases, and the wheels rapidly cut away the sides of the grooves, sometimes leaving a dangerous cutting edge on the guard rail. The flanges must be deep enough to keep the wheels on the track, and thick enough to prevent chipping when obstacles are met in the groove. A $\frac{3}{8}$-inch flange has been successfully used at Leeds on some worn rails where only half an inch depth of groove was left: $\frac{3}{8}$-inch is found too deep a flange; $\frac{1}{2}$-inch is the best standard. The objection to a deeper flange is its thinness and consequent weakness, necessitated by the restricted width of groove. One of the chief causes of breakage of flanges is the practice of increasing the gauge of track at curves without proportionately widening the rail grooves. A tread and flange well designed to suit their rails should make the flange last the full life of the wheels—*i.e.*, at least 1 to $1\frac{1}{2}$ years. A pair of "Griffin" wheels on the Dublin United Tramways lasted nineteen months and ran 52,839 miles. E. H. C.-H.

293. *Heavy Track Construction in New Orleans.* (Street Rly. Journ. 16. pp. 428–430, June, 1900.)—The New Orleans and Carrollton Railroad Company has recently put down the heaviest electric road T-rails in the States. They are of the A.S.C.E. section, $5\frac{3}{4}$ inches high, and weigh 100 lbs. per yard. Owing to the spongy nature of the soil all the track is laid on a plank flooring. An excavation about 24 inches in depth and 10 feet wide was made for each track. The bottom of this trench was then laid with $1\frac{1}{4}$-inch creosoted long-leaf yellow pine planking. On this were placed 8 inches of broken stone of a size which would pass through a $1\frac{1}{2}$-inch ring. On this stone were then placed 6 in. × 8 in. × 8 ft. creosoted yellow pine ties, sawn square, and spaced 24 inches centre to centre on straight track. Broken stone was carried up between the ties; gravel was then inserted to fill up the space up to the top of the ties, after which earth was filled in to the top of the head of the rail on the outside, and to the bottom of the head in the inside of the track. Standard

6-bolt fishplates are used. The rails are bonded with No. 0000 Standard concealed bonds, with cross-bonds at special work only. The joints are staggered and suspended. The special work is of the Lorain Steel Company's 9-inch girder "guarantee" type, joined to straight track by 100-lb. T-wing rails and cast-weld joints. E. H. C.-H.

294. *Tests of the Buffalo Street Railway Power Plant.* **R. C. Carpenter** and **H. J. Ryan.** (Street Rly. Journ. 16. pp. 646–649, Aug., 1900. From the Sibley Journal of Engineering.)—Power for the Buffalo tramways is obtained partly from their own steam plant and batteries and partly from the Niagara Falls. The Niagara Company have contracted for a continuous supply of 2,000-h.p., and the chief object of the battery is to utilise this power during light-load hours, as well as to help the generators at times of heavy load. The battery contains 272 cells of 3,000 ampere-hours capacity. The test was to determine the relative values of the three conditions of operation—(i) By steam, operating 10 units — viz., three 1,000-h.p. vertical cross-compound direct-coupled engines, six 500-h.p. vertical cross-compound belted engines, and one 250-h.p. horizontal cross-compound belted Ball engine. (ii) By Niagara Falls power operating four 500-h.p. rotary converters. (iii) By storage battery operating through a 210-kw. 70-volt booster; also to determine the efficiencies of boilers, engine, and electrical equipment. Ninety-six observers were required, and three twenty-four hour runs were made as follows: (*a*) Under normal conditions, *i.e.*, with full quota of Niagara power, with as many engines as the load required, and with battery in normal service. (*b*) Eliminating Niagara Falls power and using engines and battery only. (*c*) Eliminating the battery and using engines and Niagara power only. The boiler plant comprises sixteen Babcock and Wilcox boilers and two of the Scotch marine type, all fitted with Roney automatic stokers supplied with coal from a travelling car on an overhead track. The rated capacity of the boilers is 5,080 h.p. Full results of the boiler test are given. The average equivalent evaporation from and at 212° F. was 8·3 lbs. of water per lb. of dry coal. For the engines test 38 indicators were used and 7,344 cards taken. In the three runs the lbs. of steam per i.h.p. per hour (auxiliaries included) were, respectively, (*a*) 24·88, (*b*) 24·38, and (*c*) 25·71; the lbs. of coal per i.h.p. per hour were (*a*) 3·53, (*b*) 3·31, and (*c*) 3·64; the lbs. of water from and at 212° F. per e.h.p. per hour were (*a*) 34·1, (*b*) 33·5, and (*c*) 34·2; the lbs of dry coal per e.h.p. per hour were (*a*) 4·23, (*b*) 4·04, and (*c*) 4·17. The saving due to the use of the battery appears to be about 4 per cent. in coal, to which must be added a reduction in repairs to engines owing to steadier load.

E. H. C.-H.

295. *Stationary Batteries for Tramways.* **F. J. Stone.** (Street Rly. Journ. 16. pp. 868–869, Oct., 1900. Paper read before the New England Street Railway Club, Boston, Sept. 5.)—The author advocates the use of a battery of accumulators, either in a tramway generating station, or at some point on the line, and points out the recognised advantages of so doing. He mentions the installation of the Brooklyn Heights Railway Company, where a very heavy summer load is met, by running a battery mounted on cars to the end of a long feeder, and there leaving it connected up during the months of heavy load. G. H. B.

296. *Stationary Batteries for Tramways.* **P. W. Davis.** (Street Rly. Journ. 16. pp. 869–872; Discussion, pp. 872–873, Oct., 1900. Paper read

before the New England Street Railway Club, Boston, Sept. 5.)—The author considers the case of a line 12 miles in length with a heavy grade at a distance of 8 miles, and supposes that the increase of traffic has rendered necessary some means of maintaining the pressure at the distant end of the line. He considers different solutions of this problem, and gives curves showing the fall of pressure along the line in each case; taking the capital expenditure into consideration, he concludes that the location of a battery at the grade is the best solution. Under the original conditions the voltage falls from 575 to 76 at the grade; on installing a battery, at a cost of $4,500, the pressure at this point is increased to 313 volts. To produce the same result by an additional feeder would cost $18,500, and by a booster and separate feeder $7,500. The author further discusses the use of batteries in rotary converter substations, and the use of boosters for charging the cells.

G. H. B.

297. *Railway Power Transmission.* **J. H. Armstrong.** (Street Rly. Journ. 16. pp. 889–892, Oct., 1900. Paper read before the New York State Street Railway Association, Sept., 1900.)—There are five methods of distributing power for railway work: (1) 500-volt direct-current throughout. (2) The operation of series-wound direct-current boosters in connection with 500-volt apparatus. (3) The use of three-wire distribution, using the track as a neutral. (4) Alternating current with step-down transformers and rotary converters. (5) Alternating current transmission with three-phase motors mounted on the cars.

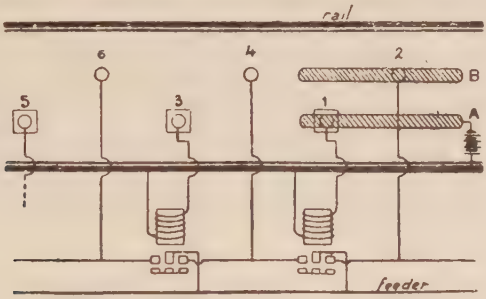
The author points out the well-known advantages and disadvantages of the first three methods.

The fourth method, with alternating current, has the advantage that the energy can be transmitted over large areas at high voltage with consequent small copper investment and small loss, and at the same time ordinary direct-current traction equipment at 500 volts can be used on the cars. Step-down transformers must always be used where rotary converters are employed, as the voltage on the alternating side bears a fixed ratio to the voltage on the commutator (about 64 per cent.). Motor generator sets may receive line voltages direct, up to 10,000 volts, but the saving of step-down transformers is off-set by the extra cost of the motor generator. Modern 25-ton suburban cars running at 40 miles an hour require on an average about 100 kw., but may demand two or three times this amount when starting or on severe gradients.

In the fifth system, where three-phase current is used throughout, the trolley or third-rail voltage being no longer confined by the limitations of the direct-current commutator, can be raised to several thousand volts if necessary. Expensive third-rail construction can, in fact, be dispensed with, as at high voltage the current is so small that with the very heaviest traffic ordinary overhead construction is possible. The position of the step-down transformers along the line is determined by the relative cost, and the cost of trolley and copper for feeders between them. As they are in use only whilst a train is passing, the step-down transformers can be made of small thermal capacity, but of large momentary overload capacity, so that, their cost being small, they can be placed comparatively close together, keeping the line-drop low and increasing the efficiency of transmission. E. K. S.

298. *Surface-contact System at Monaco.* (Street Rly. Journ. 16. pp. 361–362, May, 1900.)—The system installed at Monte Carlo by the French

Thomson-Houston Company several years ago has run most successfully. Last summer 2·8 miles were in operation. The track is laid with 72-lb. rails to metre gauge. The route is very hilly. One hill 400 metres long has a 9 per cent. rise in parts. The sharpest curve has 20 metres radius. Current is picked up by long shoes or skates under the car from contact blocks which are kept alive by section switches placed in manholes near the track. The contacts are in two rows between the rails, staggered, and each block is about 1 foot from the nearest rail. The blocks are mushroom-shaped on the surface, and are set into cast-iron boxes bolted to the ties. The pavement is of wood. One set of blocks is for carrying current to the car from the feeders. The other set is for connecting the first set with the feeders. When alive, the first set is at 550 volts, but the second set is at much lower potential. The feeders are carried in trenches at the side of the track. The section switches are of the three-pole type with carbon contacts against copper, and are actuated by electromagnets. The centre contact is connected with the feeder; each of the other two is connected to its neighbouring high-potential contact block, and also to one of the poles of the adjoining section switch. The low-potential contact blocks are connected through the magnets of the section switches to earth, as shown in the diagram. The magnetic blow-out, placed



close to the contact points, blows out any arc which might be caused when the armature of the magnet in the section switches drops. The contact devices carried on the car are two in number, as shown in the diagram, and consist of skates long enough to span the distance between two adjoining contact blocks. They are connected to the truck by springs, so as to give a continuous pressure against the blocks. The contact blocks project about half an inch above the surface of the paving. The method of operation is as follows: Contact blocks 1, 3, and 5 are those of low potential, while 2, 4, and 6 are those of high potential. Assume that the car is stopping in the position shown in the diagram. To obtain a starting-current the motor-man closes a switch connecting a small storage battery between the skate A and the ground. This gives a current through contact block 1 to the ground, and raises the armature in the first section box, connecting contacts 2 and 4 with the feeder. The car then takes current from contact 2, through skate B, and as the car is moving from right to left it soon takes current from contact 4, which is also alive. The motors are not earthed directly, but are connected to the skate A, so that as soon as the car starts the current flows from the motors through contact 1 to the ground, making it possible to cut out the storage battery. When the car proceeds so that skate A covers contact block 3, the magnet of the latter is excited by the current from the motors, making contact blocks 6 and 8 alive, and when skate A has left contact block 1 it breaks the circuit through the first section box, making contact

block 2 dead. The contact blocks are about 3 metres apart. The Company has six cars in operation, running on a headway of ten minutes. The length of each trip is about fifteen minutes. Each car has room for twenty-four passengers inside and six on each platform, and is divided into two classes. The length of the body is 8 metres, and the cars are equipped with G.E.-53 motors and B-16 controllers. E. H. C.-H.

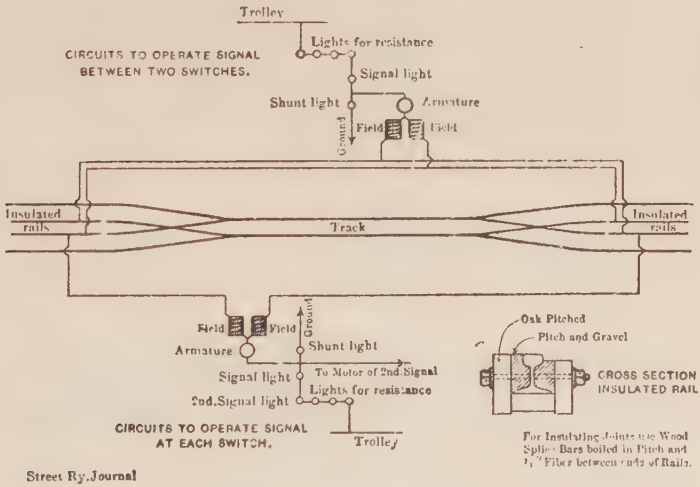
299. *Dolter's Surface-Contact System.* **E. Nelson-Uhry** and **J. Reyval.** (Écl. Électr. 24. pp. 216–221, Aug. 11, 1900.)—The car carries two electromagnets slung from the truck, the pole-pieces forming contacts which rub against studs in the centre of the track. The magnet windings are in series with the motors, between the controller and the pole-piece contact. The N. and S. poles are side by side, in positions corresponding to the two magnetically, but not electrically, insulated halves of the contact studs or discs. When the electromagnets come over a pair of studs the magnetic circuit passes through a hinged armature in a contact box below, this armature forming the short arm of a lever whose other end carries a carbon block, which, when the armature is attracted, makes contact with the feeder. After the car has passed, the carbon contacts separate by their own weight, aided by a spring. A safety trailing earth is carried at the back of the car, and this blows a fuse in the contact box if the studs have remained alive. When starting from rest, cells are used to magnetise the pole-piece contacts and make the first pair of contacts alive. The length of the pole-pieces is such that they are always in contact with one pair of studs, and consequently successive studs are made alive by them before they leave the previous stud. It is claimed that this system has not the drawbacks of the Diatto system, where satisfactory working depends on the exact level of the mercury in the contact box. Since May 30, 1900, a car on the Dolter system has been constantly in use on a line 750 metres long near Suresne. E. H. C.-H.

300. *Demerbe Tramway Rail.* **W. Dawson.** (Elect. Rev. 47. pp. 521–522, Sept. 28, 1900. Paper read before the Brit. Assoc.)—The Demerbe rail is, in section, an inverted trough with curved contour, forming on the upper surface a channel similar to that of the ordinary girder rail. The fishplate fits exactly inside the rail, and is secured to, and at the same time pressed into, the rail by two cotters, each passing through both sides of the rail and fishplate. The tie-bars are flat and set on edge; one side of the rail fits exactly into a notch in the tie-bar, while the other is secured in a wider notch by a wedge. The rail is completely filled by special tools with concrete, which becomes firmly attached to the rail, and forms a continuous and uniform support for it; and if the track be laid with a concrete foundation the rail becomes practically incorporated with it, and the two rails form one uniform structure. At Bradford 4 miles of 70-lb. Demerbe rail were laid end to end with a similar length of 105-lb. girder rail, with a view to comparing their relative advantages; the result, after six years' service, was greatly in favour of the Demerbe rail, especially as regards cost of maintenance. The costs, including laying the rails, were respectively 19s. 5·4d. per yard for the Demerbe, and 23s. 1·4d. for the girder rail. The author estimates the life of the Demerbe rail to be 25 per cent. longer than that of the girder rail. G. H. B.

301. *The Electric Railway Motor.* **J. Lundie.** (Street Rly. Journ. 16. pp. 779–783, Oct., 1900.)—The author first discusses acceleration and braking, pointing out the well-known advantages of rapid acceleration. He then

discusses the rating of motors, and proposes that the power rating of a railway motor on frequent intermittent load should be directly proportional to the average current input, independently of variations in current, except in so far as the current may be governed by the limitations of satisfactory commutation. A motor might be rated at 6,000 time-current units to operate between current limits of 100 and 250 amperes. This motor on continued intermittent service ought not to have a greater temperature rise than the one agreed upon, whether operating on 100 amperes 60 per cent. of the time, or 250 amperes 24 per cent. of the time. The author gives five curves showing temperature rise of a particular motor on different intermittent loads. R. B. R.

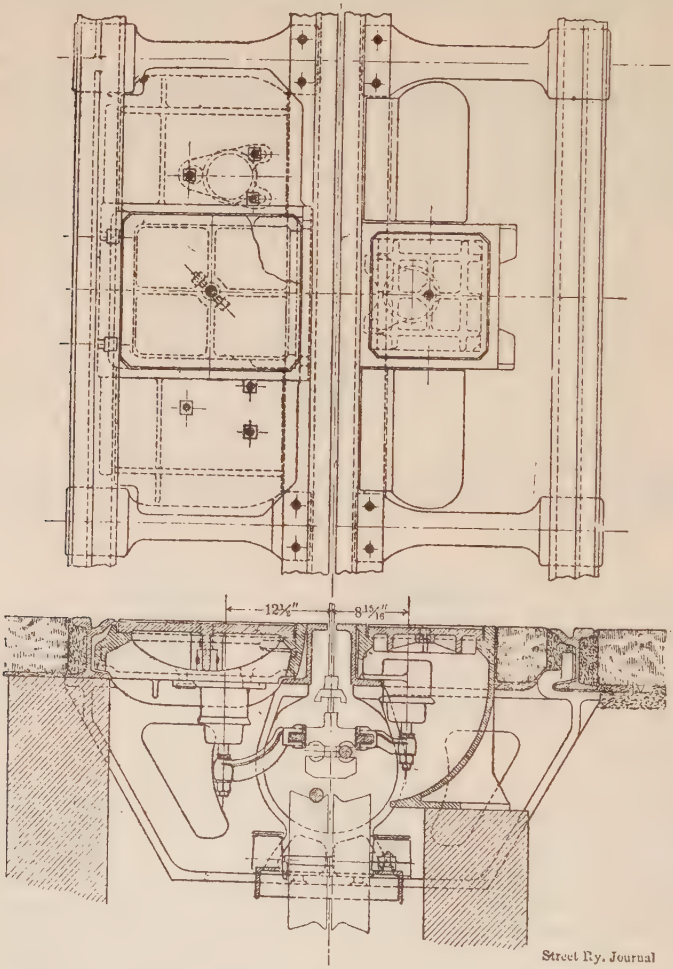
302. *Columbus Railway Company's Methods.* (Street Rly. Journ. 16. pp. 661–668, Sept., 1900.)—Some of the streets in Columbus, the capital of Ohio, are lighted from steel lattice arches spanning the streets, each carrying fifty 16-c.p. incandescent lamps. The Company own 98 miles of line radiating from the centre of the city, as well as an interurban railway from Columbus to Westerville, a distance of 15 miles. Owing to the gauge being 5 ft. 2 in., the bicycle truck is used under all double-truck cars.



The Company has successfully spliced pairs of 16-feet box cars together, making double-truck cars of light weight and large carrying capacity. Twenty such spliced cars have been in use for four years. Great importance is attached to the car wiring; all wires passing through floors or timber are protected by porcelain bushes. The total maintenance cost for all rolling stock is less than 1 cent per car mile. New track is laid with 74-lb. 8-inch T-rails on oak ties, surrounded to within 2 inches of their tops with broken stone, above which is a layer of concrete to keep the sand from sifting down from the paving blocks. Cast-welded joints are giving every satisfaction. On the interurban line an interesting automatic block signal is used between turn-outs. It consists of an ordinary signal arm operated by a connecting rod and crank on a countershaft driven by a Western Electric 16-inch fan motor. The signal is worked by the car-wheels passing on to and earthing an insulated rail to which one pole of the motor is connected (see Figure). The motor is shunted across a 50-volt lamp, so that there are only 50 volts between the

insulated rail and earth; in practice leakage reduces this to about 30 volts, which is claimed to be "too low to be noticed by any one coming into contact with the rail." E. H. C.-H.

303. *Changing from Cable Trams to Electric on Broadway, New York.* (Street Rly. Journ. 16. pp. 702–703, Sept., 1900.)—The reconstruction is being carried on without interfering with the operation of the cable cars, and as these cars run under a thirty-seconds headway during the greater portion of



the day, and as the reconstruction not only involves radical changes in the conduit itself, but renewal of all tie-rods and track rails, the task is one of no small engineering difficulty. It is done by keeping the men at work as long as possible between bunches of three or four cars, and then having them suspend operations until these cars have passed, then beginning their work again quickly. The Figure shows a cross-section and plan of the Broadway conduit as adapted for electric traction; the existing sheaves and grip are

superimposed in light lines in their correct position. The insulators, brackets, and conductors will be installed at a later date through the hand-holes and grip-hatches without disturbing the pavement, but this will be a difficult matter. If they are placed in position while the cable is in use the grip will be apt to collide with the conductors and break the insulators. On the other hand, if cable operation is stopped during the long process of introducing the insulators and conductors, the financial loss owing to suspension of traffic would be considerable. In the conversion of the Third Avenue Railroad the insulators were mounted on rods so that they could be slid to the side of the conduit and equipped. When the Company was ready to make the change to electricity the cable was stopped, and all the insulators in a section were slid forward into position together, taking a much shorter time than if all the work of placing them in position had to be done when cable operation was suspended. On the other hand, the Capital Traction Company, of Washington, D.C., in altering its Pennsylvania Avenue cable line to electricity, ran horse cars during the interruption. E. H. C.-H.

304. *Gearing for Electric Motors.* **A. H. Gibbings.** (Cassier, 18. pp. 503–509, Oct., 1900.)—Various gears are described. The Twentieth Century Speed Reducer consists of two fixed rollers and one free roller operating together by friction upon an outer cast-iron rim and on the shaft of the electric motor. The difference between the circumference of the shaft and the circumference of the rollers gives the ratio of the reduction or increase of speed. This is practically a friction gear, but slip is impossible even if the gear works in an oil bath. The Humpage gear is illustrated but not described. R. B. R.

305. *Curves on Electric Railways.* **K. Sieber.** (Elektrotechn. Zeitschr. 21. pp. 863–864, Oct. 18, 1900.)—The author points out the great disadvantages which result from the adoption, in going round a bend in the line, of a curve consisting of a circular arc which is tangential to the straight-line portions of the track. When a car is running round a curve it has two velocities—a translational and a rotational one. If we now assume that a car which has been running along a straight portion of the track is made to swing round a circular arc tangential to the straight-line portion, then the angular velocity corresponding to the particular radius of the curve and the given speed of the car must be impressed on the car within the short distance equal to its length. The angular acceleration corresponding to this will be very great, and will cause an abnormally great side-pressure on the outer rail. In order to reduce the wear and tear due to this cause, as well as to ensure smooth running, the author recommends the adoption of intermediate or transition curves between the circular and the straight-line portions of the track, the shape of the curves being so chosen as to reduce the angular acceleration as much as possible. A. H.

306. *Electric Traction Practice in France.* **A. N. Connett.** (Street Rly. Journ. 16. pp. 761–774, Oct., 1900.)—Three types of rail are in use, viz.: (i) T-rail; (ii) Double or "Marsillon" type, consisting of two small T-rails mounted on a cast-iron chair. The metal in this type is badly distributed and in new work the type most used is (iii) the girder rail. Rail specifications are very long and rigorous. The carbon is seldom specified, but in its place is the "resistance in tension," which can now be got as high as 75 kilog. per sq. mm. The older joints are generally bad, but cast-welded joints are now

being largely used with satisfaction, except on the light Marsillon rails, where a rigid cast-welded joint makes the track bumpy. All feeders are underground and almost invariably lead-covered and armoured. Junction boxes, but not wiped lead joints, are used. Draw-in systems are unknown ; the cables are laid in trenches 23 inches deep and are surrounded with sand, on top of which is placed wire netting as a warning to future excavators.

An outline is given of the conditions imposed by the authorities on electric tramways, and the chief clauses in the concession given to the "penetrating lines" into Paris in March, 1899, are set forth as typical of those now enforced. The Government telephone and telegraph lines are elaborately protected : a new law on this subject is expected in the near future. All cars must be equipped with two braking systems, each capable of stopping a car in 20 metres on a 2 per cent. down-grade at 20 km. per hour without the use of sand. If trailers are used this trial must be made with an empty motor-car and loaded trailer. The power brake must be capable of application from the rear platform independently of the motor-man ; this condition excludes electric brakes and practically necessitates air brakes, which are of three satisfactory types : (i) Stored air with charging stations at intervals, (ii) electric motor-driven compressors on the cars, (iii) axle-driven compressors. The first type is the simplest, but requires room for the reservoirs. The second is used only on the "Metropolitan" (underground). The third is chiefly used on new lines and promises well. The regulations as to brakes on trailers are so stringent that the author anticipates their replacement by long single-deck double-truck cars with central platform. Power-station practice is of no special interest.

The new lines round Nice are the first French example of a large system operated by three-phase transmission and substations from distant hydraulic power. The "Potter" surface-contact system in Monaco has proved workable for two years, and could be safely installed under similar climatic conditions. The Paris conduit lines are efficient and practical and will extend greatly. The "Diatto" surface-contact system has been adopted, on the strength of results on 2 miles of trial line, for 80 km. of the Paris "penetrating" lines. The line joining the Pont d'Austerlitz and Quai d'Orsay stations of the Orleans Railway is very successfully operated by electric locomotives, which take about fifty trains a day each way. E. H. C.-H.

307. *Brakes and Signals for Behr's High-speed Railway.* **F. J. Behr.** (Elect. Rev. 47. p. 482 ; Discussion pp. 482–483, Sept. 24, 1900. Paper read before the British Association.)—The rapidity with which a train can be stopped is limited by the discomfort occasioned to passengers. For a train travelling at 60 miles an hour this limit is reached if it be stopped in 360 yards, and for a train travelling at 110 miles an hour, in 500 yards. Brakes enabling this to be done are useful in avoiding collisions with another train, or other object visible to the driver at a distance, but no brake could be applied which would avoid small obstacles placed on the rails, or a broken rail, as the driver cannot see such obstacles until he is practically upon them.

On the proposed Manchester and Liverpool express railway, though it would be possible, in an emergency, to brake the train in less than 500 yards, the system is so designed as to render it impossible that such a case of emergency should occur. As on the proposed line there are no level-crossings or turn-outs, the only reason for stopping the train before the station would be the breakdown of the preceding train. Such a breakdown would be made

known by automatic signals for a distance of over 4 miles behind. For signalling purposes the line is divided into eight sections of 4·3 miles each, and a train, on entering each section, puts up a danger signal at that point, which danger signals are lowered only when the train enters the second section ahead, *i.e.*, at a distance of 8·6 miles. Two trains can never therefore be within 4·3 miles of one another—a condition which renders superfluous any emergency brake. Should a train pass a danger signal this is shown in the driver's cabin, so as to be visible in case of fog. G. H. B.

308. *Behr's High-speed Railway.* **W. H. Preece.** (Elect. Rev. 47. p. 482, Sept. 21, 1900. Paper read before the British Association.)—The monorail system of high-speed railway, projected by Behr for passenger traffic between Manchester and Liverpool, was first designed by Lartigue in 1882. A line between Listowel and Ballybunion in Co. Kerry was engineered by Behr and opened in 1888. The line is 9¼ miles long, with one intermediate station, and is worked by steam. The cost was £3,060 per mile. Several breakdowns have occurred in the rolling stock, but none in the line, and during twelve years' work no renewals of plant have been required.

The Manchester and Liverpool express will be more massively built; the generating station will be at Warrington, at the centre of the line; from this, power will be transmitted at 10,000 volts to substations at intervals of 4 miles, where the pressure will be reduced to 1,000 volts. The train will consist of one coach weighing 45 tons and seating 64 passengers; the headway will be 10 minutes, and the speed 110 miles an hour. To reach this speed in 110 seconds, 1,600 h.p. will be required, and to maintain it on the level, 500 h.p. G. H. B.

309. *Meynier and Legros Electric Automobile.* **A. Soulier.** (Ind. Élect. 9. pp. 379–382, Sept. 10, 1900.)—The author describes an electric car in which the special feature is the motor. This has two independent ring armatures, revolving round an internal fixed field coil. The armatures are provided with radial commutators and are mounted on a divided shaft from which the rear road wheels are driven by single reduction-spur gears. The usual form of differential gearing is thus dispensed with. Points claimed for this form of motor are very small losses due to magnetic leakage, and ability to dissipate rapidly the heat generated by the current, owing to the angular velocity of the armature being great, although the revolutions per minute may be comparatively small. The battery consists of 48 Fulmen cells each with 17 plates; it is divided into two parts, one being placed under a sort of bonnet in the front of the body, while the remaining cells are stored below the seats and are accessible from the back. The two sets are ordinarily in series, but for the slowest of the four forward speeds they are in parallel. The whole of the mechanism is mounted upon a rectangular channel steel underframe. Plan and elevation drawings of the car are given, which show clearly the distribution of the various parts. Steering is by a hand-wheel, which controls the pivoted axles of the front wheels through a spur gear, and a novel combination of connecting links, shown clearly in the plan view. C. R. D'E.

310. *Siemens and Halske Electric Tram-Omnibus.* (Automotor Journal, 4. pp. 600–601, Sept. 1900.)—The vehicle described is constructed to carry eighteen persons, and is intended for use in connection with an electric tramway system. It is a four-wheel single-deck car carrying a storage battery of 200 cells which supply current to two motors geared independently to the rear road wheels.

It is intended that in crowded parts of towns where trams cannot be used the electric car shall run as an independent motor vehicle ; but on reaching an available tram line in the less-crowded parts the car is run by the trolley, and the cells charged, the idea being an extension of the "mixed system." In order to guide the car on the track and to give the necessary earth, a frame carrying two wheels of the gauge of the tram line is lowered when the line is reached. The vehicle illustrated (photograph) is designed to have an independent radius of action of about 20 km., and weighs, fully loaded, 6 tons. C. R. D'E.

311. *Lindstrom Electric Motor Cars.* (Automotor Journal, 4. pp. 559–561, Aug., 1900.)—A form of electric vehicle is described in which two independent motors are employed, driving the road wheels through single-reduction gear. The framework of the car is a tubular structure in which the members are specially arranged to allow of flexibility of movement between the front and rear axles in their vertical planes, and at the same time to preserve the parallelism of the axles and a rigid distance between the vertical planes in which they lie. The motors are spring-hung at one end and at the other are pivoted about the rear axle, so that each forms the radius bar for its own gear. Special forms of band-brakes are also described, reference being made to the British Patent No. 4619 of 1900. A feature is made in these cars of using pressures of from 104 to 120 volts instead of the pressure of 80 volts at which the motors for most electric vehicles are worked. The Hewitt-Lindstrom Company of Chicago construct, amongst other vehicles, one guaranteed to carry eighteen persons, 56 miles on one charge at a maximum speed of 9 miles per hour. This car weighs 2·5 tons, has two 4·5-h.p. motors, and 60 cells of 19-kw. capacity at 25 amperes. C. R. D'E.

312. *Hub Electric Automobiles.* (Electrician, 46. p. 19, Oct. 26, 1900.)—A novel type of American electric automobile is described, in which the whole of the propelling mechanism, *i.e.*, motors and gearing, is enclosed in the hubs of the driving wheels. In the two-seated car the rear wheels are driven, while in the four-seated car all four wheels have motor hubs. Each motor hub consists of a four-pole field magnet, which forms the hub of the wheel, and into the exterior of which wooden spokes are driven. Within the field there revolves a drum armature free upon the end of the fixed axle. On the outer extremity of the armature sleeve is the commutator, while at the inner end is a spur wheel which drives an internal toothed ring on the hub through a pinion mounted on a fixed pin. The ratio of gearing thus obtained is 5 to 1. In the larger car a ratio of 12 to 1 is similarly obtained. Suitable rubbing contacts convey currents from a 44-cell battery to the motors, which are always in parallel, the cells being in four groups, which may be connected in series or in parallel by means of a controller. A good sectional drawing of the motor wheel is given. C. R. D'E.

313. *Mildé Electric Carriage.* **A. Delasalle.** (Locomotion Automobile, 7. pp. 610–613, Sept. 20, 1900.)—The special feature in this design is the two-wheel motor tractor, which may be combined with any form of carriage body, and which replaces the ordinary steering wheels and fore-carriage. On it are all the principal mechanical parts—viz., motor, storage battery, and transmission gear, the whole being pivoted on a central pin, which, together with a suitable guiding sector, forms the connection between the carriage and the tractor. Steering is effected by turning the tractor about this pin, the

operation being controlled from a hand wheel on a vertical spindle. This is connected by a pitch-chain gear to a short spindle having a spur pinion which gears with the teeth cut on the guiding sector of the tractor. The storage battery is carried in a box suspended below the axle of the tractor in such a manner that it can be easily detached for recharging. The motor has two independent armatures revolving in a common field, the ordinary differential gear being suppressed. The road wheels are driven direct from the ends of the armature shafts by single-reduction spur gear. Two photographs of complete carriages, and a plan and elevation of the tractor are given.

C. R. D'E.

ELECTRIC LAMPS AND LIGHTING.

314. *Efficiency of Incandescent Lamps.* **G. Weissmann.** (Écl. Électr. 24. pp. 356–360, Sept. 1, 1900. Paper read before the International Electrical Congress at Paris.)—The author gives figures showing that the practical efficiency of incandescent lamps varies from 3·5 watts per candle for a 100-volt 32-c.p. lamp, to 5 watts for a 5-c.p. lamp, while for 200-volt lamps the efficiency varies from 4 to 5 watts per candle. He quotes Blondel and Weber to show that thick filaments give a higher efficiency than thin ones, and are less sensitive to variations of pressure. Lamps of 16 c.p. at 22 volts were constructed by the author to give an efficiency of 1·67 watts per candle, and, after burning 200 hours, 1·93 watts per candle. He therefore proposes a system of internal wiring where a small transformer is employed for each lamp, or group of lamps, to reduce the pressure to about 20 volts. Such transformers can be made small enough to be concealed in the base of the lamp fitting, giving efficiencies of 85 to 96 per cent. The author claims an economy of about 45 per cent. in running lamps on this system.

G. H. B.

315. *New Incandescent Lamp.* (Scientific American, 83. p. 213, Oct. 6, 1900.)—At the Paris Exhibition there was shown a new process of glow lamp manufacture called the Malignani process, in which the vacuum is obtained in the bulb by the absorption of the gases by certain chemical substances, red phosphorus being generally used. Red phosphorus, formed into a somewhat liquid paste, is introduced by means of a piece of cotton on a wire into the tube by which the bulb is exhausted, and the walls of the tube are coated with the paste. A vacuum of one millimetre is first obtained by an air pump. Hydrocarbon gases are then introduced into the bulb; the pump is operated for half a minute, while a current is sent through the filament to bring it to dull redness. When the vacuum has been made as nearly complete as possible by the air pump, a stronger current is sent through the filament, and the outside of the bulb is heated by a small gas furnace placed below it to remove all moisture. When the vacuum has reached a certain point a light blue discharge appears at the positive pole, and eventually fills nearly the whole bulb; at this point the lamp is sealed off below the connecting tube. The red phosphorus on the walls of the tube is then heated, and it absorbs the remaining portion of the gases; at this point the discharge appears to fill the whole of the lamp. Upon heating the lamp for a few moments the discharge disappears, and the vacuum is complete. The glass tube is then sealed off and removed from the bulb.

The advantages claimed for this method are that the vacuum is better, the operation is more rapid, and it does away with the inconvenience of using mercury pumps.

E. C. R.

316. *Rating of Incandescent Lamps.* **A. J. Rowland.** (Frank. Inst., Journ. 150. pp. 241–272, Oct., 1900.)—The author emphasises the importance of exact knowledge of the candle-power of glow lamps, and states that, as lamps are usually installed, the most useful part of the light is that thrown out by the lower hemisphere towards the tip. Examining various common types, the author finds that, when giving 16 c.p. at right angles to the axis, a lamp with U-shaped filament gives only 5 or 6 c.p. along the axis towards the tip; with single-curl filament, 7 to 8 c.p.; with double curl, about 11 c.p. The last-mentioned is therefore the most effective; it is best made without a sealing-off tip at the end of the bulb. Diagrams are given showing the distribution of light with the various shapes of filament; the double U filament gives the most uniform distribution, but the author maintains that most of the light is wanted under the lamp, in which case the double-curl filament is the best. A large number of curves representing the horizontal and vertical distribution of candle-power about the various types of lamp are reproduced, and discussed in detail. The author next deals with the rating of lamps, and points out that the ordinary methods are very incomplete. As a complete determination of the mean spherical candle-power in every case is out of the question, the National Electric Light Convention has recommended that the candle-power be tested in a direction inclined at an angle of 45° with the axis of the lamp while it is rotating at 200 to 250 revolutions per minute. A number of comparative data showing the results obtained by various methods of rating are given below:—

Candle-Power Taken.	Candle-Power.				
	Single U-shaped Filament.	Single Curl Filament.	Long Curl Anchored Filament.	Double Filament.	Double Curl Filament.
(*a*) At 180 revs. with axis vertical .	16	16	16	16	16
(*b*) Mean horizontal (average of 12 readings)	15·8	16·2	16·6	16·0	15·72
(*c*) Mean horizontal (from plotted values)	16·0	16·7	16·7	16·1	15·6
(*d*) Mean spherical (standard method)	12·7	13·5	13·75	13·2	13·8
(*e*) Mean with axis at 45°	10·5	12·0	11·7	12·0	14·0
(*f*) Mean hemispherical	14·3	14·5	14·6	14·0	14·5
(*g*) Mean within 30° from tip	8·7	10·3	8·7	7·9	10·9
(*h*) From the tip	5·7	8·35	7·05	4·8	10·1

The author advocates the rating of lamps by the candle-power along the axis (line *h*); the measurement would be independent of the position of the filament, and rotation would not be necessary. Tables of efficiency referred to the various ratings given above, and of cost of energy per 16-c.p. lamp per 500 hours, are given and discussed; and the candle-power diagram (in a vertical plane) of a new form of filament giving large axial c.p. is reproduced. This filament, taking 61·6 watts at 116·3 volts, had a mean horizontal c.p. of 16·6; mean spherical c.p., 16·1; mean with axis at 45°, 16·5 c.p.; mean hemispherical c.p., 16·6; axial c.p., 15. The efficiency was 3·72 watts per c.p. (mean horizontal). The filament is of the double-curl type, flattened axially, and the bulb is also flattened.

In the discussion, **W. C. L. Eglin** exhibited a reflector lamp, and said that the horizontal light falling on the walls was important in illumination. An appendix by **A. J. Rowland** compared the reflector type of lamp with those considered in the paper, and pointed out its limitations. A. H. A.

317. *Series System for Incandescent Street Lamps.* **A. B. Proal.** (Elect. World and Engineer, 36. pp. 327-329, Sept. 1, 1900.)—At each point there are two lamps, one being in the series circuit and the other in parallel across the terminals but having a paper spark-gap. If the first lamp burns out or is broken the spark-gap breaks down owing to the rise in voltage, and the second lamp is thus put in circuit. In case the second lamp also burns out before an inspector's visit, a second spark-gap breaks down and cuts out the lamp. This second lamp has one terminal connected to a metal cylinder over which passes a strip of paper wound on two drums; resting on the paper there are two contact springs joined to the two main terminals, these springs forming with the metal cylinder the spark-gaps referred to.

It has been found by former experience that much trouble in high-tension work is caused by iron in contact with porcelain, as rust forms and is deposited on the porcelain, thus leading to large leakage and subsequent burn-outs. Copper and brass are therefore used in such places.

The system has been in operation for a year, and works perfectly.

It is stated that in series systems employing inductive shunts across the lamps the energy spent in the shunts amounts to 16 per cent. of the total.

W. H. E.

318. *Charging for Electrical Energy.* **E. de Fodor.** (Écl. Électr. 24. pp. 431-434, Sept. 15, 1900. Paper read before the International Electrical Congress at Paris.)—In order to encourage the demand for electricity during the summer months the author proposes to offer rebates varying inversely as the demand. The average number of hours of use per lamp per annum at Budapest is 440, divided as follows :—

Jan., 60	April, 29	July, 10	Oct., 50
Feb., 50	May, 19	Aug., 14	Nov., 64
March, 36	June, 12	Sept., 29	Dec., 57

These months are divided into three classes, according to the demand, and all energy consumed in any one month in excess of the corresponding mean value for that month is paid for under rebates as follows :—

October to February, 20 per cent. ;
March to May, and September, 40 per cent. ;
June to August, 60 per cent.

No demand indicator is required, the rebates being based upon the number of lamps installed on a consumer's premises. A. H. A.

REFERENCE.

319. *Ford Electric Car.* (Automotor Journal, 5. pp. 31-35, Oct., 1900.)—Description of the latest form of car described in Abstract No. 1295 (1899).

TELEGRAPHY AND TELEPHONY.

320. *The Dynamo and Storage Battery in Telegraph Offices.* **W. J. Camp.** (Canad. Elect. News, 10. pp. 170–171, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—Since 1880 primary batteries have been abolished in many large towns in America and Canada in favour of the dynamo and accumulators for telegraph purposes, both for single, duplex, and quadruplex. In some cases the dynamo is used without storage. For double current two dynamos may be used with opposite poles to bus-bars and to earth. Resistances are interposed in the several time circuits to equalise the currents going out, or else dynamos of varying voltages to suit the various circuits are employed. One form of resistance consists of German-silver wire wound on thin tubes, heat being thus carried off. Local circuits are also operated in multiple from a dynamo giving, say, 6 volts. Sometimes the dynamos are operated from a common shaft driven by an electric motor or other power, but the plan most generally adopted is to use motor generators, each machine working independently. For security of working, spare leads are run to different power stations, and spare machines are also in readiness. Transformers are employed where necessary to reduce the pressure where the current is taken from street railways or town mains. The writer states that the working of the lines has been much improved and a great economy effected. Diagrams and descriptions of joining up for duplex and quadruplex are given.

E. O. W.

321. *Pollak-Virag Telegraph.* **C. H. Garland.** (Elect. Rev. 47. pp. 628–633, Oct. 19; and 651–652, Oct. 26, 1900.)—The first form was a specially constructed telephone with optical and photographic attachments to register the vibrations of a diaphragm thrown into motion by currents following in very rapid succession. [Abstract No. 433 (1900).] It was demonstrated that the marks registered varied in character with the direction of the current, and also with the strength and duration of the current. The impression of the light-ray upon the sensitised paper could thus be elongated either in a vertical or a horizontal direction. But the curves of letters written with a pen are not fully produced by this method, the parts following only in horizontal sequence. Two telephones are now employed, each having a fine rod projecting from the centre of its disc and connected with the mirror which is to reflect the light upon the sensitised strip. The mirror is magnetically attached to three points, to one of which it is fixed, but about the other two it is movable. When the telephones are acted upon by suitable currents the mirror may be caused to describe movements which trace written characters upon the strip.

A metallic circuit is required for one of the two telephones, the other being interposed between the first and the earth. The perforations on the sending-tape are divided into two series, of which one sends the vertical components of the letters of the alphabet, whilst the other series furnishes the horizontal components, the telephone in the metallic circuit being concerned with the former and that in the earthed circuit with the latter. The roller over which the tape passes has five separate metallic sectors, over which perforations in five different lines on the tape pass, and the necessary contacts are made by

ve brushes bearing on the upper surface of the tape. The perforations iffer in size, and being also different in position it will be readily understood hat currents of varying strength, direction, and duration can be sent to line y a proper arrangement of the perforations. Three sectors of the roller ommunicate with the metallic circuit only and two with the earthed circuit, nd the little rods of the telephone discs are brought into play accordingly.

The disturbances due to the proper or self-vibrations of the telephone nembranes are overcome by shunting each telephone by a condenser. Inuction coils are also used in shunt with the sending-contacts to eliminate or orrect induction disturbances. The sensitised paper after being exposed to he spot of light passes downwards through an automatic fixing and developng apparatus, from which the message emerges ready for use. It is stated hat six thousand ten-word messages per hour can be sent with the Pollak-Virag apparatus. The trial made over a metallic loop of 400 kilometres in length at Buda-Pesth, having a resistance of 2,000 ohms, showed that one housand words per minute could be transmitted with perfect legibility and ccuracy. E. O. W

322. *Key-board for the Hughes Printing Telegraph.* **G. Conradt.** (Elektrotechn. Zeitschr. 21. pp. 773-775, Sept. 13, 1900.)—Since the keys which may be depressed during one revolution of the chariot must be separated from each other by at least four keys, and since there are twenty-eight keys on the key-board, it is only possible, under the most favourable circumstances, to print five characters in each revolution. The greater the number of keys that can be depressed up to this limit the greater is the capacity of the instrument. Instead of arranging the keys in alphabetical order as heretofore, the keys are arranged as follows :—

| | | |

through a relay. These relays are so adjusted that the weakest current just suffices to cause their armatures to be attracted. When the current is momentarily interrupted by a further movement of the lever of the paper-shifting and starting switch, one relay drops back. This causes the current normally flowing through the magnet, controlling the paper-shifting mechanism, to be momentarily interrupted, and the release and re-attraction of the armature of this magnet causes the paper to be moved on by a mechanical grip. The other relay is used for signalling. In order to enable the pen at the receiver to be lifted from and returned to the paper with the pen at the transmitter, a bar is provided beneath the receiver pen, this bar being normally raised by a magnet in a local circuit. The pressure of the pencil on the platen at the transmitter effects the closure of the primary circuit of a small induction coil, of which the secondary transmits a vibratory current to line through a condenser ; this current energises a relay at the receiving end which breaks the circuit of the magnet controlling the pen-lifting bar at the receiver, and so allows the pen to return to the paper. Details are given of the signalling devices, which comprise telephones. The paper is illustrated by photographs and diagrams. C. K. F.

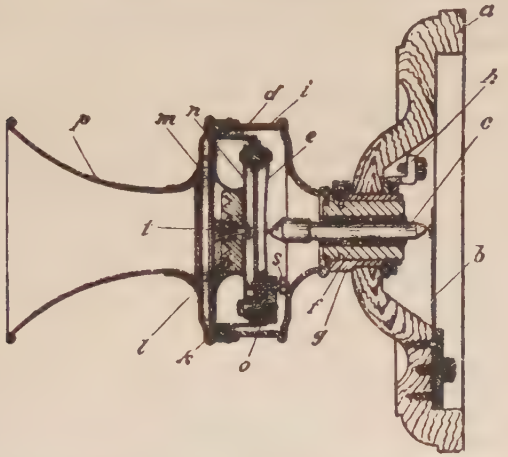
324. *Erratic Currents on Submarine Cables under Repair.* **H. G. Barwell.** (Electrician, 45. pp. 816–817, Sept. 21, 1900.)—These are noticeable by kicks on the galvanometer and intermittent buzzing of a telephone connected between the core of the picked-up end and the sea. They are explained as being due to small changes in the capacity of the cable caused by variation of the resistance of the contact between the respective sheathing wires at a splice, these variations being due to varying strains. If the depth of water is known, and the first indication of the splice being disturbed is noted on the telephone, an approximate idea of its distance from the ship may be obtained. M. O'G.

325. *Telephone Exchange at Munich.* (Elektrotechn. Zeitschr. 21. pp. 714–720, Aug. 23 ; 735–740, Aug. 30 ; and 755–760, Sept. 6, 1900.)—The main feature of this new exchange, which is designed for 10,800 lines with complete metallic circuits, consists in that the drop indicators are replaced by small incandescent lamps. By this means an attendant can serve 100 lines instead of 80. A full description, illustrated by working drawings, diagrams, and photographs, is given of the whole of the plant. C. K. F.

326. *Breguet's Telephonic Transmitter.* **L. Montillot.** (Électricien, 20. pp. 164–166, Sept. 15, 1900.)—This arrangement has a d'Arsonval microphone ; four carbon pencils are vertically supported in pairs between fixed horizontal carbons, of which the upper is common to the four, while below there are two blocks, one for each pair of uprights. These latter are partly covered by sleeves of sheet iron, and behind them is a magnet regulator movable by an adjusting screw, which acts upon the carbons through the medium of the iron sleeves, and presumably limits or amplifies their movements according to the adjustment. The necessary contact springs, contact-maker, microphone, and induction coil are all arranged symmetrically in one plane upon an upright board, and the receiver hook and lever, in place of carrying contact springs, is caused to move up and down a rod moving in guides with a cross-piece which engages with the springs. When the telephone is on the hook the rod is vertically at its highest point, in the middle of the board, and presents means for allowing the press button to be used. The arrangement is employed by the French Government. E. O. W.

327. *Microphone Transmitter.* **J. Baumann.** (Zeitschr. Elektrotechn., Wien, 18. pp. 479–481, Sept. 30, 1900.)—This telephone transmitter is specially designed for long-distance working, and is the type adopted in the German Post Office.

Referring to the drawing, *p* is the mouthpiece conducting the sound waves to the circular carbon plate *m*, which is protected by a grid. Against the middle of the disc *m* rests a woollen pad *t*, secured to the centre of the grooved carbon disc *l*, and serving to damp the vibrations of the disc *m*. The disc *l* is surrounded by a ring of fabric, the upper edge of which is fringed out, and the threads forming the fringe are cemented round the edge of the disc *m*, so as to form a space between *m* and *l* to receive the granular carbon. The disc *l*



is mounted on a flat spring *n*, which can be adjusted by means of a screw *s*, so as to regulate the pressure of the granular carbon against the plate *m*. These parts of the instrument are contained in a metal casing *i*, which surrounds the edge of the plate *m*, and conducts the current to it. The current enters at the screw *h*, and passes through the tube *g* to the casing *i*. From the granular carbon the current passes through the plate *l*, the spring *n*, spring *e* and pin *c* to the spring *b*. Platinum contacts are provided on the pin *c* and springs *b* and *e*. This arrangement of contacts is designed to permit the easy removal of the microphone, which can be taken out directly on opening the casing *i*. The position of the granular carbon can be altered by turning the tube *g* in the base *a*. C. K. F.

328. *Leopolder's System of Bell-signalling and Telephonic Communication for Railways.* **A. Prasch.** (Zeitschr. Elektrotechn., Wien, 18. pp. 445–448, Sept. 9, 1900.)—In this system, which is used on the Austrian State Railways, there are sets of signalling and telephonic apparatus at each pair of adjacent stations, and at the intermediate signal-boxes. The stations are each provided with bells sensitive to alternate currents only, arranged in series with bells sensitive to direct currents only; and the signal-boxes are provided with bells sensitive to alternate currents only; whilst both the stations and signal-boxes are fitted with small magneto-machines which are capable of supplying either alternate or direct currents as desired, the station machines normally giving alternate currents, and the signal-box machines normally giving direct currents,

the change from alternate to direct, or *vice versâ*, being effected by depressing a key. A switch is provided at each station whereby the magneto-machine or the telephonic apparatus can be connected to either of the adjacent signal-boxes or stations. By this means each station can ring the signal bells both at another station and at a signal-box ; or, on depressing the key, can ring up the station only by means of a direct current.

There is also described a device which automatically gives a definite series of signals, and consists of a clockwork train driven by a weight and adapted to drive the magneto-machine. This main train can be controlled by auxiliary trains which each correspond to a definite group of signals and keep the line-circuit closed whilst these signals are given, the number of these auxiliary trains corresponding to that of the lines to be served. A diagram of connections of the whole system, and a diagrammatic side elevation of the automatic signalling device are given in the original paper. C. K. F.

329. *Contact Force.* **E. Piérard.** (Revue de l'Él. 9. p. 116, Aug. 15, 1900.)—The author's experiments were referred to in Abstracts Nos. 1226 and 1971 (1900). This is a somewhat similar account. He concludes that in his circuits there is an open heterogeneous chain of metals at different potentials due to contact force (which depends not only upon chemical composition, but also upon the physical state of the surfaces in contact), and that a certain electric charge results. When the contact between the point of the vibrator and the plate takes place the chain is closed, the electromotive forces come into equilibrium, and a current passes through the circuit. The electric flow is renewed at each contact. E. O. W.

330. *Western Electric Company's Multiple Switchboard with Central Battery.* **J. Anizan.** (Journ. Télégraph. 24. pp. 198–202, Sept., 1900.)—This, the latest development, is in use or being adopted in many towns in Europe for boards of varying capacity, from 1,200 jacks at Bucharest to 13,000 at Vienna ; the London Post Office will have one of 5,000 lines. In America 100,000 lines were served on this system this year, and the number will soon be 300,000. The proposed London system was referred to in Abstract No. 1,765 (1900). A lamp lights up over the subscriber's jack when he takes his telephone off the hook ; it is extinguished when the operator plugs in. If, while getting communication the caller goes away and replaces his telephone another lamp lights up behind the cord of his plug. Each cord has one of these lamps ("signals of control") in addition to the lamp over the individual jack ("signal of call"). When two subscribers are conversing the "cord" lamps are extinguished, so that the operator is aware that they must not be disturbed. When the telephones are restored the "cord" lamps light up and the plugs are removed by the operator. These lamps are all worked by relays, and of course take the place of annunciators. Visual signals made with painted shutters worked electromagnetically can be used instead of lamps. In the latest arrangements the subscriber's telephone receiver is not in the direct-line circuit as formerly with the secondary of the induction coil, but makes with one winding of a transformer, the other winding of which is to line, a shunt to the polarised bell. The microphone, also shunted, is in series with the parallel coils of this transformer, the current being of course derived from the central battery at the exchange. E. O. W.

331. *Intercommunicating Telephone System.* **W. S. Henry.** (Amer. Electn. 12. p. 443, Sept., 1900.)—The author describes with diagrams improved

means by which, without a central exchange, subscribers can, upon one circuit, selectively communicate with each other. [See Abstract No. 2525 (1900).] Each station has a selective switch; there is a separate wire for each station, connected, however, to the appropriate stud in all the switches. There is also a common return wire, and also a battery wire, where one ringing battery only is provided for the whole circuit. To prevent inconvenience by reason of the user leaving the selective switch off the home stud the vibrating bell is permanently connected to the home button and to the common return wire through the rest contact and lever of the telephone, so that the bell must ring when any other station calls the station in question. The person called up would then, in order to speak, have to properly adjust his own switch. If magneto-generators and polarised bells are used, the battery wire is dispensed with, the bells are put in circuit in the same way as in the preceding arrangement, and the generators are put in between the home studs, push-buttons, and selective switches. A further method dispenses with a common battery and its separate wire, and employs a battery in each station for both ringing and talking. The battery is in circuit with the selective switch, the push-button, and the return wire. It is also, for speaking purposes, in circuit with the pivoted end of the telephone lever, the primary coil, and the microphone. E. O. W.

332. *Multiple Switchboard for St. Etienne.* **L. Montillot.** (Électricien, 20. pp. 65–72, Aug. 4; and 100–106, Aug. 18, 1900.)—A full description with useful diagrams of a board exhibited at the Paris Exhibition. There are few novel features. A relay is used in the test circuit. It is in circuit with the tips of the plugs, the restoring battery, the test wire, and the test contacts of the jack. When it is required to ascertain whether a line is free or engaged the tip of the plug as usual is made to touch the brass rim of the jack, and the relay closes if the circuit is complete, that is, if a plug is anywhere in a jack of this line. When the relay closes a local battery is put in circuit with the operator's receiver and a click is heard. If there is no click the line is free and can be joined over. The relay in this arrangement is in duplicate, so that if one is not working properly, the second can be brought into circuit by operating a special "changing key." The "test" circuit is absolutely independent of the line circuit.

The cables behind the jacks are made up flat, in thicknesses of 6 mm. or under, corresponding to the handles of jacks, and each row is on a lath or rod capable of being lifted up to allow of examination of the cable next below. They are said to be more convenient than round cables. E. O. W.

333. *Telegraphone.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 1–3, Oct. 6, 1900.)—The principle of the telegraphone can be demonstrated by comparatively simple apparatus. An endless band of thin steel is stretched between four brass rollers set at the four corners of a long rectangle. It passes twice round the top pair of rollers and then twice round the lower pair, so that there are two vertical lengths of band, one at each end of the rectangle. The "speaking" apparatus consists of an electromagnet whose poles are fixed near to the band at one or other of the vertical stretches. A second electromagnet, connected in series with a telephone, is placed with its poles near to the band at the second vertical stretch of the steel band. The "speaking" electromagnet is connected in series with the secondary windings of a transformer, the primary of which is connected with a microphone and accumulator. The electromagnets are each constructed of two cylindrical cores,

with two ends opposed, in the same straight line; the opposed ends are fixed just out of contact with the steel band, and transversely to it. The cores are 20 mm. long and 1 mm. diameter, made of best Swedish iron. The "speaking" electromagnet is wound with 2,000 turns of 0·1 mm. copper wire. The second electromagnet is wound with finer wire, and with more turns. An electromotor is used for driving the rollers; the rate is adjusted so that the band moves at about 3 m. per second. The whole of the band passes any given position once in two minutes. As it comes into the field of the "speaking" electromagnet it receives a magnetic impression which it transmits mechanically to the second electromagnet, for reproduction in the telephone. The author says that when a palindrome, such as "Ein Neger mit Gazelle zagt im Regen nie," is spoken into the receiver, it can be distinguished at the telephone whichever way the band is directed. The distance between the receiver and the telephone is not stated. R. A.

334. *Kumberg "Telephonograph."* (Electrician, 45, p. 828, Sept. 21, 1900.)—This is a combination of the phonograph with the telephone. By a simple mechanical device inside the electromagnetic diaphragm call the vibrations of the diaphragm are increased and caused to cut impressions in the coating of a cardboard cylinder 10 inches long and 5 inches in diameter. By revolving the cylinder, record is made at 150 spirals to the inch, and the number of words which may be taken down on one cylinder is some 15,000, equal to a page of ordinary newspaper. There is also a second cylinder, concentric with and at one end of the other, and $\frac{1}{10}$th of its width, the function of which is to take the place of an attendant and to answer calls. The "automatic speaker," in circuit with the microphone mouthpiece and pressing upon this smaller cylinder, can be used to impress a notice upon this cylinder that the subscriber is out, but that a message can be received for him and recorded upon the large cylinder. There are levers for putting each stylus in or out of circuit. When left in circuit for the purpose of receiving messages the movement of the cylinder takes place automatically and is controlled by the person at the distant end of the line who is making the communication. E. O. W.

REFERENCES.

335. *Wireless Telegraphy.* **M. Minolts.** (Elektrotechn. Zeitschr. 21. pp. 808–811, Sept. 27, 1900.)—The Borkum Riff lightship, Borkum lighthouse, and Emden are now in communication by wireless telegraphy. A very good description of the apparatus is given. R. A.

336. *Hertzian Telegraphy with a Telephonic Receiver.* (Electrician, 46. pp. 93–94, Nov. 9, 1900.)—The results of experiments, undertaken by Guarini, are given, and various deductions are made.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1901.

GENERAL PHYSICS.

337. *Atwood's Machine.* **R. Malagoli.** (N. Cimento, 12. pp. 33–35, July, 1900. From Memorie della Società degli Spettroscopisti Italiani, vol. 28, 1899.)—The author investigates the history of Atwood's machine and its modern representatives. It was first proposed by Schober in 1751, and brought out by Atwood in 1784 at Cambridge. Of the modern improvements, that in which a continuous cord is used, so as to equalise the amount of cord on both sides of the pulley, is the most valuable. Even so, however, the error of the machine is not under 2 per cent. E. E. F.

338. *Lecture Experiments in Elasticity.* **W. S. Franklin.** (Phys. Rev. 11. pp. 75–78, Aug., 1900.)—The writer considers it extremely important that students should obtain a clear idea of the character of homogeneous strain, viz., three mutually perpendicular stretches, and that they should see the applicability of the notion of homogeneous strain to the small parts of a body non-homogeneously strained. Now as most students are not sufficiently acquainted with solid geometry to get a clear idea of the strain ellipsoid, the writer finds it useful to use the distortion of an elastic sheet as an illustration in two dimensions. An extremely thin sheet of rubber, slightly oiled with a non-mineral oil to make it semi-transparent, is stretched over a frame 15 to 20 cm. square. This state of the sheet is taken as the normal or unstrained state, and small circles (also a large circle) are marked on it. These small circles can be projected by a lantern. The sheet may now be stretched homogeneously, the sheet being fastened to the frame by a number of spring clips, and the circles are seen to be changed to similar and similarly placed ellipses. Stretching the sheet non-homogeneously the small circles are changed to dissimilar and dissimilarly placed ellipses; the large circle, however, differs from an ellipse. It is also instructive to show the distortion of square figures marked upon the sheet.

In the discussion of shearing strain the writer uses a large square hinged frame, over which muslin cloth is stretched, the threads of the cloth being parallel to the sides of the frame. The reduction of a shearing strain to two diagonal stretches mutually perpendicular is most clearly shown by drawing

a large circle on the muslin. This circle is changed by the distortion to an ellipse with its axes diagonal to the frame. In the discussion of strains and stresses in a twisted cylinder the writer uses a large tin cylinder covered with muslin, which is fastened to the cylinder at one end and to a loose circular disc at the other. Squares and circles marked upon the muslin show very clearly the strains produced when the circular head is slightly turned.

At the end of the paper the writer gives an outline of what he considers the most satisfactory elementary development of stress-strain relations, which he thinks are not satisfactorily treated in any of the text-books. E. C. R.

339. *Torsional Rigidity of Wires under Longitudinal Stress.* **J. R. Benton.** (Ann. d. Physik, 3. 3. pp. 471–491, Nov., 1900.)—The torsional rigidities of wires of different metals under longitudinal stress are here experimentally determined, the lateral contraction being measured and the rigidity moduli being calculated on the reduced sections. The metals used are steel, iron, copper, nickel, brass, nickeline, German silver, red brass, and bronze. In all the metals except nickel the rigidity modulus diminishes with increased load. The rigidity modulus is represented by the formula—

$$m = \alpha + \beta P + \gamma P^2,$$

where P is the stretching force and α, β and γ are constants. The values of β and γ are given in tables in the paper, and these vary with the diameter of the wire used, presumably owing to the influence which the outer surface layers of the wire exert on the torsional rigidity. As the diameters of the wires are increased, β and γ approach more nearly to constancy.

The experimental method used is the vibrational one, and a special optical micrometer employing Newton's rings is used to measure the lateral contraction. J. B. H.

340. *Rates of a Rocking Watch.* **C. Barus.** (Phil. Mag. 50. pp. 595–604, Dec., 1900.)—A watch mounted in a hard wood ring is suspended on a knife edge placed parallel to the axis of the watch and so that the natural period of the pendulum, thus formed, is approximately the same as the period of the balance wheel. The watch when left to itself rocks permanently to and fro through a considerable angle and lends itself beautifully to the study of the interference of two nearly synchronous vibrations. The problem is complicated, however, by the vibrations of the pendulum not being simple harmonic while those of the balance wheel are.

A comparison of the rate of the watch while thus suspended with that of a good chronometer shows that the balance wheel in these conditions has two distinct periods, one longer than its natural period and the other shorter, the period changing from the one to the other after the lapse of certain intervals of time. The interval during which the short period lasts is longer than that during which the long period lasts, and consequently the rate at which the watch gains time in the former is less than the rate at which it loses in the latter.

By adding little weights at the bottom of the ring the moment of inertia of the pendulum is altered, and these rates are correspondingly altered, the rate at which the watch loses time on the long period increasing continuously with increased moment of inertia, while the rate at which it gains time on the short period diminishes correspondingly.

The author applies the theory of a system of two degrees of freedom as given by Rayleigh in his treatise on Sound. He also shows how these

experiments illustrate Rayleigh's theory of anomalous dispersion, and finally he considers the application of the apparatus as a differential gravity meter, the rate at which the watch loses on the long period being a sufficiently sensitive measure of g. J. B. H.

341. *Nature and Velocity of Gravitation.* **R. A. Fessenden.** (Science, 12. pp. 740–745, Nov. 16, 1900.)—The present article supplements the work dealt with in Abstracts Nos. 1233, 1234, 1235, 1277, 1278, and 1279 (1900), and Abstract No. 20 (1901). Taking Boys' value for the gravitational attraction of two masses, the author finds 10^{-45} erg as the gravitational energy of one of J. J. Thomson's corpuscles. From this and the electrostatic stress the volume elasticity [of the ether] is made of the order 10^{73}. The density and rigidity of the ether have previously been calculated to be 0·66 and 6×10^{20} respectively. Whence the velocity of the compressional or gravitational wave is calculated to be approximately 5×10^{36} cm. per second. E. H. B.

342. *Conductivity of Copper containing Phosphorus and Arsenic.* **A. Rietzsch.** (Ann. d. Physik, 3. 3. pp. 403–427, Nov., 1900.)—An extension of Matthiessen and Holzmann's work on the great decrease of conductivity of copper by addition of phosphorus or arsenic. The thermal and electric conductivities (K_T, K_E) of copper bars and plates containing varying quantities of the above substances are measured. K_T for the rods is found by Wiedemann and Franz's apparatus and method; K_T for the plates is measured by Voigt's method. A rectangular plate is made up of two different metals joined along the diagonal; it is painted with a solution of 0·35 gm. elaidic acid in 5 c.c. absolute alcohol. The short end of the plate is then placed on a copper block at 100° and removed when the melting of the coating has reached a certain point on the diagonal. The relative conductivities are then as the tangents of the angles between the isothermals and the diagonal. K_E is measured by a null method. Tables of results are given. Four curves show the intimate relation between K_T and K_E. Values for pure copper being taken as 100, the curves of variation of K_E and K_T with addition of P or As are almost coincident, that for K_E being slightly above that for K_T. Also, the correction of the Wiedemann-Franz law of proportionality of K_T and K_E is for copper containing phosphorus and for arsenical copper in the opposite direction to that found by Jaeger and Diesselhorst for mixtures of purely metallic substances. G. E. A.

343. *Lambert's Theories.* **C. Chistoni.** (N. Cimento, 12. p. 36, July, 1900. Atti della Società dei Naturalisti e Matematici di Modena, serie 11, vol. 1, pp. 66–88.)—In this work the author attempts to render more precise Lambert's conceptions and definitions concerning the reflection of light and heat, and the cooling of bodies. In connection with the latter, he discusses especially Newton's law. E. E. F.

344. *Atmospheric Radiation.* **F. W. Very.** (U.S. Weather Bureau, Bull. G., No. 221, pp. 5–134, 1900.)—The investigation was commenced in 1892 at Alleghany Observatory and continued later at Providence, R.I. The radiation was measured with a bolometer (Langley's early type) consisting of thin strips of blackened platinum, arranged in two series. The ideal aimed at in the experiments was to obtain a concave surface of silver (silvered copper) at constant temperature, having the bolometer at its centre of curvature completely filling the circular openings in the multiple screens of

polished metal; volumes of hot and cold air were rapidly substituted between the bolometer and the outer screen. As the radiating power of a gas is very low in comparison with the emissive power of a solid, the mirror was coated with lampblack which, it was supposed, would retain substantially the temperature of its metallic backing. As the method did not prove satisfactory, the bolometer was pointed to a cold screen entirely separated from the hot air which issued from a flue. Finally the experiments on the radiations from air, carbon dioxide, aqueous vapour, and other substances at reduced pressures, and from multiple flames, were conducted in a closed chamber fitted with a rock-salt window; this apparatus tended to leak when heated so that high temperatures could not be applied. The paper describes the standardising of the apparatus and the methods employed, dwells on Reid's bolometer formula, and discusses the results obtained with especial reference to Tyndall, Langley (in whose work the author assisted), and Paschen.

Gaseous water produces a very potent influence of its own; but the absorption increases decidedly with incipient condensation. The relation of aqueous absorption and radiation is complex. The radiations of clouds, the sea, and of moist earth and of vegetation, do not much differ from the radiant emission of a solid black body, whose spectral energy has, at terrestrial temperatures, its maximum in the immediate vicinity of the chief aqueous absorption bands. The position of this maximum absorption varies with the amount of water in the atmosphere and with its physical state; and the position of the maximum of the unabsorbed energy curve also varies with the temperature of the radiating body and of the surface to which it radiates. A highly absorbent gas, which is also a powerful radiator in thin layers, may become a poor radiator with greater depths. The small masses of the mixed gases and vapours of the laboratory radiate chiefly by their most highly radiative molecules, the others transferring their heat to these kinetically; whilst in the large masses of the atmosphere the feebly radiative molecules act as the chief radiators, except in their outer layers. The radiation proceeds, in deeper layers, slowly from one portion of air to a colder neighbouring portion. There seems to be a certain analogy between dry air and rock-salt; both emit waves of great length, and are poor radiators in small masses, and better ones in thick layers. The radiation of homogeneous air of moderate depth appears to depend, for a given temperature, merely on the product of density and depth; but the absorption of a given mass of aqueous vapour is smaller when distributed through a large volume of air than when concentrated. As an absorbent of terrestrial radiations, water vapour is much more efficient than any other constituent of the atmosphere; but as radiators, when in large masses, the constituents do not differ very widely, and the carbon dioxide and the gases may also be the chief radiators, according to the temperature and the depth of the layers.

The atmosphere produces a selective scattering, particularly of the short waves; the light is further diffracted by minute ice crystals and reflected more indiscriminately by coarse dust particles; but the rays, which are taken out of the beam in this way, do not alter the temperature of the air, and a large portion of them reach the earth. It is different with the line and band absorption, because that energy is transformed into energy of molecular or atomic movement, and remains in the air as an increase either of its sensible or its latent heat. As the composition of the atmosphere is continuously changed by emanations from the earth and its inhabitants, the atmospheric thermal energy is increased in this manner. This increase of temperature is

lost again by radiation which, being obstructed downward by the greater density and humidity of the lower strata, is mainly diverted outward. In a measure, the emission of the air resembles its absorption, but it is confined to the longer waves; the radiations of oxygen, nitrogen, argon, and krypton at low temperatures remain to be explored. As regards the solar spectrum the absorbent action of carbon dioxide and of the gases is almost invariable; but the absorption bands of aqueous vapour and the selective scattering of short waves are much stronger in summer than in winter. For this reason the direct winter sunrays appear more powerful than the summer rays; the rays are less potent in the tropical zone than in the temperate zones, and less at sea-level than on mountains. The heat entrapped through the differential transmission of solar and terrestrial radiations is mainly stored in the lower strata. The gradual accumulation of moisture in the higher strata during the summer gives us the warm autumns; the opposite reason explains the cold spring season. Temperatures lower than —73° C. possibly cannot occur on the earth on account of the almost total absorption of all radiations beyond 13 μ. Cooling of moist air by radiation cannot be responsible for large rainfalls, as, owing to the peculiar absorption of its own rays, the radiation can only proceed through a thin surface layer which will soon become saturated by the cooling. In the higher atmospheric strata cooling by radiation plays an important part. H. B.

345. *Formation of Hailstones.* **A. Artom.** (Elettricità, Milan, 19. pp. 690–692, Nov. 3, 1900.)—The author puts forward a theory of the formation of hailstones, based on the rotation of an insulator in a partially insulating fluid medium, when subjected to an electric field. In hail-forming clouds the requisite conditions for such rotation obtain; the highly insulating frozen particles are in air charged with very fine drops of water, this forming a medium with relatively low insulating properties; an electric field then determines a rotation of the frozen particles, which thereby come into contact with and congeal the surrounding liquid drops. The author claims that the stratified formation of hailstones tends to confirm this theory. G. H. B.

346. *Hail and Hail-dispersing Cannonades.* **W. Weiler.** (Elekt. Runds. 18. pp. 33–34, Nov. 15, 1900.)—The author draws attention to the renewal of Volta's hail theory by Marangoni, and to the thunderstorm theory of A. Krebs. The former accentuates the low elevation of the hail clouds; the firing would shake these clouds, dispersing the water globules, and would prevent their up-and-down motion and their freezing. The latter ascribes the formation of thunderstorms to whirls which the air column, discharged from the gun, would destroy. H. B.

347. *Action of Hail-dispersing Guns.* **G. Gastine** and **V. Vermorel.** (Comptes Rendus, 131. pp. 766–768, Nov. 5, 1900.)—In order to study the air column, issuing from the gun, the authors constructed targets of iron wires, 2 mm. thick, 10 cm. apart, fixed in a wooden frame, 5 m. sq., and covered with paper. At a range of 60 or 80 m. a ring was torn out of the target, 2 m. in diameter and 20 cm. in width; a similar ring was obtained with a smaller gun at 6 m. range. The effect is due to a ring-shaped whirl which is deflected by the ground, trees (which it strips of leaves), and houses, even if they are some distance from its path. It is therefore difficult to hit the target, and the whirl projectile may be deflected by a right angle after striking an obstacle. It

travels slowly with a hissing noise. Lumière Brothers have taken photographs with a kinematograph at intervals of $\frac{1}{17}$ second, with good results; and Grandvoinnet has photographed a whirl 3 m. in diameter. H. B.

348. *Rock Temperature at Sydney Harbour Colliery.* **J. L. C. Rae, E. F. Pittman,** and **T. W. E. David.** (Roy. Soc. N. S. Wales, Journ. and Proc. 33. pp. 207–223, 1900.)—The observations were made in 1899, in accordance with the recommendations of the Brit. Assoc. Committee on Underground Temperature, and partly with their instruments (slow-action and maximum thermometers), at the Birthday Shaft, Balmain, Sydney, which was already 600 feet deep, and this has since been carried down to a depth of 1,449 feet, and will be sunk to 3,000 feet. The thermometers were placed at intervals of 50 feet in horizontal holes, from 3 to 5 feet deep, which were left open for from 34 to 84 hours after insertion of the thermometers; strings were attached to the thermometers, and their copper cases were plugged with greasy cotton waste and clay. Withdrawal followed after a minimum period of 37 hours. So far an average rise of temperature of 1° Fahr. per 90·7 feet has been observed; the curve, however, is irregular. The paper records in detail the strata, chiefly sandstones and shales, often less than a foot in thickness, and refers to the water circulating in the strata. H. B.

349. *Magnetised Chronometers and Terrestrial Magnetism.* **A. Cornu.** (Comptes Rendus, 131. pp. 859–865, Nov. 26, 1900.)—Since the steel parts of an accidentally magnetised watch do not come into actual contact, there is no reason why such a watch, if it is not altogether stopped, should afterwards stop occasionally, provided that all magnetic dust has been removed. The author had a very badly magnetised demi-chronometer thoroughly cleaned, but not demagnetised. When placed horizontally in different meridians it continued to go regularly for years, the deviations from uniform movement (not more than a few tenths of a second per day) depending upon the azimuth. The observations were confirmed by compensating the magnetism of the watch; the magnetic orientation then had no more influence. The movement follows a sinusoidal law, just as a watch whose balance is not in perfect equilibrium behaves, according to Phillips, under the influence of gravity when placed in a vertical position. Chronometers on board ship, and particularly on iron vessels, are, therefore, affected by the variation in the terrestrial magnetic field, resulting from changes in the course steered and other causes, because no balance will be entirely free of magnetism. Corrections are, however, possible. The shielding action of iron boxes should be further studied both in observatories and on board ship. H. B.

350. *Cause of Polar Lights.* **S. Arrhenius.** (Phys. Zeitschr. 2. pp. 81–87, Nov. 10; and 97–105, Nov. 17, 1900; from the Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, p. 545, 1900.)—This is really a cosmical paper. In order to explain the apparent repulsion of comets' tails by the sun, the author starts from the hypothesis, first advanced by Euler, clearly shaped by Maxwell, and quite recently established experimentally, it is said, by Lebedejew, that the light waves exercise a pressure on the surface which they illuminate. That pressure would be much stronger on the sun's surface than near the earth, and would, on the sun, for a substance opaque to light rays, be able to counterbalance the influence of gravity on a cubical particle having an edge of 10^{-4} cm. A spherule of density 1 and diameter $1{\cdot}5\,\mu$ (or of diameter $0{\cdot}3\,\mu$ and density 5) would no longer be attracted by the sun;

a smaller particle would be repelled. From the curvatures of two selected comet tails, Bredichin has calculated that this repellant action of the sun must be respectively 18·5 and 1·5 times the force of gravity; if we assume that the comets consist of hydrocarbons of density 0·8, the spherules forming those tails could not be larger than 0·1 and 1·25 μ respectively. These figures are not absurdly small, as there are organised bacilli of smaller size. When a comet approaches the sun a boiling process goes on in the advance portions; the gases may be condensed to drops or soot particles, and form the advance tails occasionally observed. Cosmical particles may come from the faculæ and produce the rays of the corona. Most of this matter would fall back into the sun, some particles are repelled into space. The electric discharges occurring on the sun produce kathode and Röntgen rays, which ionise the particles; the negatively charged particles, which serve as condensation nuclei (C. T. R. Wilson), travel and meet celestial bodies, electrify them, are again repelled, and form a cosmical shadow behind these bodies which, owing to the deflection of the particles, will be wider than the optical shadow. The day-side of the earth is exposed to such a rain of negatively charged particles. They are arrested in the highest strata of our atmosphere, at an altitude of perhaps 200 km., and produce kathode rays when discharged by ultra-violet light; the auroræ are kathode-ray phenomena. They are not visible in those high altitudes, because the air is too rarefied, and they do not produce more than a luminous glow (with the auroral line) in the equatorial belt, which receives most particles, because there the magnetic lines of force lie parallel to the earth's surface. Near the poles, where the magnetic lines are vertical, the kathode rays can penetrate more deeply into the atmosphere. This hypothesis is in accordance with the various periods of auroral frequency: the sun-spot period, equatorial maxima and solstital minima, synodical sun period, tropical moon, and diurnal earth period. The latter particularly are almost obscured by the sunshine and moonshine periods; but the real frequency maximum of auroræ seems to fall in the early afternoon (Gyllenskiöld). This hypothesis also explains the zodiacal light; the disturbances, annual, diurnal, and auroral, of the magnetic elements; the heterogeneous character of certain meteorites; and, further, the glow of stellar nebulæ. What we see glow in the probably cold nebulæ is the outer least dense layers, in which the cosmical particles are caught and discharged; we perceive only the hydrogen and helium lines because the denser substances are in the inner strata. H. B.

351. *Danish Polar Light Expedition to Iceland*, 1899–1900. **F. Neesen.** (Deutsch. Phys. Gesell., Verh. 2. 15. pp. 218–220, 1900.)—A preliminary account of this expedition, in which A. Paulsen, La Cour, and Moltke took part. The author exhibited the water colour and oil paintings which Moltke had made on the spot after his own pencil sketches. One aurora shows a multiple arc with rays, the others strange luminous waves. In one instance a wheel with doubly curved spokes was observed; there was no rotation about the centre of the wheel, though the white or greenish-white light was in constant motion. The spectrum photographs mark lines and a continuous spectrum between 407 and 470 $\mu\mu$; the continuous spectrum is probably due to moonlight; the lines agree, according to Scheiner, with the kathode lines of nitrogen as to position and intensity. Observations of atmospheric electricity were taken on fifty-three days, but were successful on eleven days only, owing to snowstorms; the minimum air potential occurred at about three or four o'clock in the morning, the maximum about noon. The magnetic needle was but little disturbed, and was never deflected by more than 3°, whilst deflections of 10° had been

observed in East Greenland; but the quiet arc was at right angles to the meridian, and some of the auroræ were at high altitudes, up to 400 km. A positive current was apparently flowing from west to east. H. B.

352. *Total Solar Eclipse, May* 28, 1900. *and Research during Eclipses.* **R. Gautier, A. Riggenbach,** and **A. Wolfer.** (Archives des Sciences, 10. pp. 193–209, Sept.; and 329–344, Oct., 1900.)—The first part of this paper is a report of the instrumental equipment and results obtained by the expedition, consisting of the above astronomers, to Ménerville, in Algeria.

The second part of the paper gives a summation of the various points on which it would be advisable to direct inquiry. The main problems are as follows:—

(1) *Corona.* (*a*) Relation of streamers to prominences; (*b*) Position with regard to sun's axis; (*c*) Variation of form with time, long and short period; (*d*) Rotation; (*e*) Spectrum; (*f*) Polariscopic, photometric, and calorific measurements.

(2) *Reversing Layer.*

(3) *Prominences.* Varying forms of same prominence as photographed or seen in lines of different refrangibility.

(4) *Intramercurial planets.* C. P. B.

353. *Suggested Explanation of the Solar Corona.* **W. Huggins.** (Astrophys. Journ. 12. pp. 279–280, Nov., 1900.)—This note is in answer to a former article by Scheiner [see Abstract No. 2400 (1900)], and gives extracts from the Bakerian Lecture, 1885, showing that the *direct solar radiation* origin of the corona was then considered probable by the writer (Huggins). Reference is also made to Huggins' presidential address to the Brit. Assoc. 1891, p. 1, in which he concludes that the corona is caused in a similar manner to the tails of comets, that is by matter going from the sun under electrical forces. The new results of Langley and Newall are yet under discussion, but are likely to supply important additional information. C. P. B.

354. *Observation of Corona in Daylight.* **R. W. Wood.** (Astrophys. Journ. 12. pp. 281–286, Nov., 1900.)—The author describes a series of experiments undertaken at the Lick Observatory to try the possibility of detecting the corona during daylight by methods based on the eclipse observation that some 15 or 20 per cent. of the coronal light is polarised. The results were so far negative, but several suggestions are given for future work. C. P. B.

355. *Distribution of Minor Planets.* **de Freycinet.** (Comptes Rendus, 131. pp. 815–821, Nov. 19, 1900.)—The article is a somewhat longer and more complete discussion of the question of the distribution of the zone of asteroids than that first communicated [Abstract No. 1628 (1900)]. On the assumption that these small bodies are the product of disruption of a former ring of matter revolving round the central body, he calculated the mean eccentricities of the several rings into which it might be expected to divide. On examination of the elements of the 428 of the present known planets, it has been possible to divide them into eight groups, the members of each group having similar eccentricity and inclination of orbit. The numbers of separate bodies in each zone vary greatly—from 1 to 170. The mean thickness of the rings is 0·278, the radius of the earth's orbit being taken as unit—the individual rings varying from 0·22 to 0·36. In each ring the mean eccentricity of the members situated in the inner or inferior half is greater than that of the members

occupying the superior or outer half; and comparing two rings, it is found that the mean eccentricity of the planets in the inferior part of the outer ring is greater than that of those occupying the superior part of the inner ring. In one ring—the fifth—consisting of 69 planets, the mean eccentricities of the two halves are identical, and it will be interesting to examine the places occupied by asteroids discovered in the future as to their effect on the constants of this region of the minor planetary swarm. C. P. B.

356. *Escape of Gases from Planetary Atmospheres.* **G. Johnstone Stoney.** Roy. Soc., Proc. 67. pp. 286–291, Nov. 14, 1900; also Astrophys. Journ. 12. pp. 201–207, Oct., 1900.)—This problem has been mainly investigated by three writers—Stoney, Cook, and Bryan. Stoney has previously considered Cook's view of the question [see Abstract No. 1988 (1900)], and in the present paper the inquiry is dealt with in the manner put forward by Bryan. He brings forward several conditions which would probably render unavailable the supposition of partition of energy among the atmospheric molecules. The chief of these are (*a*) the fact that a body may have two kinds of temperature, radiation and conduction; (*b*) the influence of the field of force due to the earth, &c., in which the molecules have to move; (*c*) the continual variations introduced by the many disturbances produced in the atmosphere. He, on this reasoning, concludes that the restriction of the Boltzmann-Maxwell law within our atmosphere is a mistake, and therefore that the inferences from it are not a real interpretation of the facts of nature. C. P. B.

REFERENCES.

357. *Gerschun's Proposed Method for the Determination of the Density of the Earth.* **A. Sella.** (Archives des Sciences, 10. pp. 322–323, Oct., 1900.)—The author deals mathematically with this method [see Abstract No. 442 (1900)] with a view to testing its feasibility. E. H. B.

358. *Meteorological Observations in Geneva, 1899.* **R. Gautier.** (Archives des Sciences, 10. pp. 345–363, Oct.; 467–484, Nov.; and 539–556, Dec., 1900.)

LIGHT.

359. *Colour Produced by Simultaneous Contrast.* **G. J. Burch.** (Roy. Soc., Proc. 67. pp. 226–228, Nov. 14, 1900.)—The author here describes a new method of studying the apparent changes produced in the colours of a spectrum when the colour of the background is changed. An ordinary stereoscope is used, one field having a blue glass background and the other one of red glass. In front of the aperture by which light is usually admitted when viewing opaque pictures two slits are placed, and a grating is placed in each eyepiece. The first order spectrum of each slit appears near the centre of the corresponding field, and the slits are arranged so that on looking through the stereoscope the two spectra are seen side by side. To prevent the direct mixing of the colours of the spectra with those of the backgrounds two black patches are put on each of the backgrounds, so situated as to correspond exactly in position with the spectra.

On looking through the spectroscope two spectra are seen side by side on a field, the colour of which continually oscillates from red through purplish grey to blue. The spectrum connected with the red glass shows little or no red, but a splendid green and an equally splendid violet; while that belonging to the blue glass has the red well developed, the green pale and dingy, and the blue almost absent. By varying the coloured glasses or superposing others on them different results are obtained.

Hering's contention, that contrast phenomena originate in the eye rather than in the mind, is substantiated, but the complementary colour to red is shown to consist not of one simple colour-sensation but of two at least, namely, green and violet, and in the author's case also blue. A magenta ground is complementary to a spectral green, but on adding a yellow glass to the magenta one to cut out the violet rays the violet reappears in the complementary spectrum, while, if a blue glass is added instead, the violet vanishes and red stands out brightly in the spectrum. The colour which has green for its complementary is thus shown not to be spectroscopically simple.

J. B. H.

360. *Transparency of the Atmosphere.* **C. Chistoni.** (N. Cimento, 12. pp. 35–36, July, 1900. Atti della Società dei Naturalisti e Matematici di Modena, serie 3, vol. 16. pp. 165–187.)—The author reduces to modern terms and methods the researches of Bouguer on atmospheric absorption, and summarises the work done in the same connection by Pouillet, Violle, Maurer, Angot, Forbes, Crova, and Radau. E. E. F.

361. *Acetylene, particularly as a Photometric Standard.* **E. L. Nichols.** (Frank. Inst., Journ. 150. pp. 356–387, Nov., 1900.)—A description of some properties of the acetylene flame regarded as a laboratory adjunct, and, to some extent, a compilation of results of some previous investigations. It is found that the luminosity of acetylene depends very much on the age of the gas. A gasometer filled with acetylene was found in five months to contain about 25 per cent. of acetylene, and the degenerated gas had only 6 per cent. of the illuminating power of freshly made acetylene. Also the illuminating power of acetylene made by dropping small lumps of calcium carbide into water is 20 per cent. greater than that of acetylene prepared by dropping

water on the carbide. A gas pressure regulator and a spectro-photometer used in the investigations are described, and the paper further treats of the illuminating power of mixtures of C_2H_2 and H_2, of the stability of the flame, its intensity in different directions and with different burners, its power as compared with other illuminants and its value as a photometric standard.

G. E. A.

362. *Thermodynamics and the Magneto-Optical Faraday Effect.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 2. 14. pp. 206–210, 1900.)—In this paper the author disposes of the seeming contradiction of the laws of thermodynamics in the problem presented by Wien first in 1894 and again in his Paris address on the theoretical laws of radiation.

The seeming paradox is as follows: Suppose two similar black elements at the same temperature to have two Nichol prisms placed between them, the one rotated 45° relatively to the other, and suppose that between the prisms a magnetic field exists which rotates the plane of polarisation by 45°. The radiation from the element A towards the element B passes first through prism 1 and is polarised. It then passes through the magnetic field, and the plane of polarisation is rotated through 45°, so that on reaching prism 2 it all passes through the prism to B. The radiation from B towards A, however, after passing through prism 2 and the magnetic field, is polarised in a plane perpendicular to the plane of prism 1, and no radiation passes through. It thus appears B receives more radiation from A than A does from B. Planck shows that the radiation from B to A, supposed parallel after passing prism 2 and the magnetic field, is totally reflected by prism 1; it then again traverses the magnetic field, and the plane of polarisation is rotated so that the radiation is totally reflected by prism 2; it then traverses the field for the third time, and the plane of polarisation is rotated so that the beam passes through prism 1 to A. The two elements thus receive the same amount of radiation.

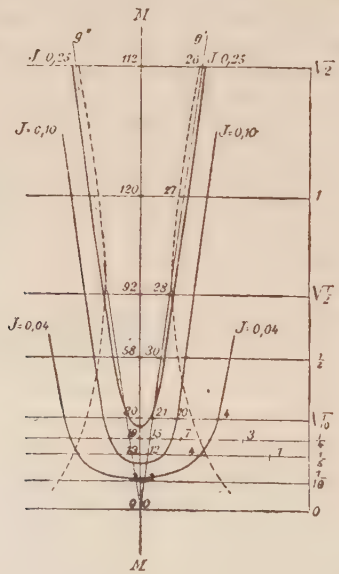
The author afterwards considers the general problem in which the angle between the planes of the prisms is ϵ and the rotation by the magnetic field is α.

J. B. H.

363. *The Kathode Stream and Röntgen Light.* **W. Rollins.** (Amer. Journ. Sci. 10. pp. 382–391, Nov., 1900.)—A summary and discussion of current opinions. The author holds that a space of strained ether is necessary for the production of kathode rays; that the particles of the kathode stream repel one another and come to a focus (from a concave kathode) beyond the place required by the accepted theory; that the direction of the particles in the kathode stream is not independent of the position of the anode at high vacua; that the kathode stream particles are not always of the same size, moving with the same speed and carrying the same charge, for from a mercury kathode they are heavier and fail to set up Röntgen rays, producing ordinary light instead; that the kathode stream is due to gas amalgamated with the kathode and stops when this is exhausted; that ultra-violet light impinging on a kathode will not cause a kathode stream; that the radiations from a radio-active "kathode" in a kathode tube cause radiations differing from Röntgen rays, being diffused in the tissues of the hand like ordinary light. The theory of indivisible atoms is not now admissible; no more is the idea that the particles in the kathode stream are ultimate components, for their spectrum is too familiar, too complex, and not new. Trowbridge obtained the spectrum of water vapour.

A discussion of opinions follows as to the Röntgen rays. The author holds these to be short ether waves due to impact and heating of the impinging particles, which become radiant centres and thus cool down. If the area struck by the impinging particles is kept very cold there is less Röntgen radiation. The transparency of aluminium to Röntgen radiation is inconsistent with the ordinary solid atom theory, but is consistent with a theory that aluminium atoms and kathode-stream sub-atoms are made up of ultimate atoms proportional in number to the atomic weight, and themselves identical for all elements, and that there is ether between these. A platinum target faced with aluminium is not an efficient reflector of Röntgen rays, as on the transparency theory it ought to be, and it would appear that the aluminium atom is a more open structure than a platinum atom. A. D.

364. *Diffraction of Röntgen Rays.* **A. Sommerfeld.** (Phys. Zeitschr. 2. pp. 55–60, Oct. 27, 1900.)—Mathematical study of the theory of abrupt impulses, revised, corrected, and continued [*cf.* Abstract No. 1798 (1900)]. It is ascertained that the method of Huyghens' principle, in the sense of Kirchhoff's formulation of the same, is applicable, as a means of getting



sufficiently approximate results, when the breadth of the impulse is sufficiently small. The accompanying diagram summarises the conclusions. The slit is a triangular one, exaggerated in its dimensions. The scale at the side shows what proportion the corresponding breadth of the slit bears to $\sqrt{8\lambda x}$, where x is the distance from the slit, and λ is the breadth of the impulse. The figures down the mid-line show the values of the intensity, which rises to a maximum at a breadth equal to $\sqrt{8\lambda x}$, and then falls off (the numerals being given a hundredfold value, 120 for 1·20, and so on). The curves $J = 0{\cdot}04$, $= 0{\cdot}10$, and $= 0{\cdot}25$ show lines of equal intensities. The dotted lines show where the intensity is equal to one-fourth of what it is opposite the centre of the slit, and it is seen that the narrower the slit the more uniform is the intensity on the screen, and the farther does the proportional brightness

extend beyond the geometrical shadow. If we take the line $\int = 0{\cdot}25$ as marking the limit of what can be photographed, and also take the substantial widening as taking place at the same level, we find that this level corresponds to a slit-breadth of $\sqrt{1/10} \cdot \sqrt{8\lambda x}$. In Haga and Wind's experiments this limit was reached at a slit-breadth of $9 \cdot 10^{-3}$ mm. at a distance of 75 cm., whence $\lambda = 1{\cdot}3 \times 10^{-7}$ mm., a value much smaller than that given in the previous paper, but preferable. It approximates to molecular dimensions, which accounts for many of the peculiarities of Röntgen rays. Some of Haga and Wind's results are to be accounted for by the Röntgen rays presenting an admixture of impulses of different breadths. The disturbances here studied form a limiting case, at the opposite extreme to the regular oscillations studied in Optics. A. D.

365. *Alternating Currents and Radiography.* **P. Villard.** (Archives d'Él. Médicale, 8. pp. 502–509, Oct., 1900.)—Description of apparatus. A transformer is described converting alternating current at 110 volts and 7 or 8 amperes to 50,000 volts effective, 70,000 maximum. In the secondary circuit there is a pair or a number of pairs of condensers, to limit the quantity in the secondary circuit to an amount determined by the capacity of the condensers. Across the secondary circuit, beyond the condensers, a Villard electric valve (Archiv. d'Électr. Méd., May, 1899, p. 181) which allows discharges only in one direction through itself, and therefore only allows the opposite discharge to affect the Crookes tube, which thus is traversed by discharges in one direction only. The voltage in the Crookes tube is also increased by the use of this electric valve. Arrangements are also described for dividing and distributing the secondary current, as, for example, for stereoscopic radiography with two Crookes tubes alternately illuminated. Crookes tubes work very smoothly with the arrangements described, as if the regular alternating action of the transformer and condensers were beneficial. On the whole the results resemble those obtained by means of a static machine, and the effect on a photographic plate may be still further improved by laying a very thin metallic film on the plate so as to cut off the less penetrating radiations. A. D.

366. *Phosphorescent Glow in Gases.* **J. B. B. Burke.** (Electrician, 45. p. 936, Oct. 12, 1900 (Abstract). Paper read before the Brit. Assoc., 1900.)—Phosphorescent glow produced by electrodeless discharge can diffuse in gases, and if the diffusion take place through a narrow brass tube put to earth, so that no ionised particles can accompany it, the phosphorescent glow which has traversed this brass tube is relatively very persistent, and it is electrically conductive. A. D.

REFERENCES.

367. *Blue Colour of the Sky.* **N. E. Dorsey.** (Monthly Weather Rev. 28. pp. 382–389, Sept., 1900.)—A historical account of the theories as to the colour and polarisation of the light from the sky, concluding with a bibliography of works on the subject. J. J. S.

368. *Iris Diaphragm in Radioscopy.* **A. Béclère.** (Archiv. d'Él. Médicale, 8. pp. 510–519, Oct., 1900.)—Description of apparatus and discussion of the advantages obtained in medical work by diminishing the effect of secondary radiations and adjusting the area of the field of view so as to obtain the maximum definition consistent with adequate illumination of the field. A. D.

HEAT.

369. *Underground Temperature at Oxford.* **A. A. Rambaut.** (Roy. Soc., Phil. Trans. 195. pp. 235–258, Nov. 22, 1900 ; Abstract in Roy. Soc., Proc. 67. pp. 218–222, Oct. 31, 1900.)—The monthly means of the readings at noon for the year 1899 of five platinum resistance thermometers, buried one below the other in undisturbed gravel at depths 119½, 68½, 42½, 18, 6½ inches respectively, and of a standard mercury thermometer in a Stevenson screen were expressed by Fourier series in which a yearly and a half-yearly wave were alone taken into account. The respective amplitudes due to the annual wave were 5·102°, 8·305°, 10·581°, 13·305°, 15·411°, 12·878° Fahrenheit, and their retardations in phase were 202·71°, 230·18°, 243·48°, 256·40°, 264·39°, 262·77° ; comparison of the first four amplitudes in pairs gives numbers between 0·1191 and 0·1222 for the value of $\sqrt{(\pi/\kappa)}$, where κ is the diffusivity of gravel, and lengths are measured in Paris inches, and comparison of the first four retardations gives numbers between 0·1141 and 0·1202. The mean of all is 0·1189, which is the same as that (0·1187) obtained from the semi-annual wave, though in the latter case the individual numbers lie between 0·0949 and 0·1445 : and these four thermometers agree in giving 15·65° and 2·92° as the respective amplitudes of the annual and semi-annual waves at the surface of the gravel. Discrepancies between theory and the observations are not wanting, but these are not larger than may be *a priori* expected. R. E. B.

370. *Radiation of Black Bodies.* **O. Lummer** and **E. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 2. 12*a*. pp. 163–180, 1900. In substance this paper was communicated to the Physical Section of the Naturforscherversammlung in Aachen on September 18, 1900.)—The authors have extended their observations on the distribution of energy in the spectrum to wave-lengths between 12 μ and 18 μ, and temperatures between 85° and 1800° abs., confirming their previous conclusion that Wien's law is invalid. Discrepancies occur between the observed values and the values calculated from this law, which amount to one-half of the observed values at high temperatures. The differences are exhibited by plotting the observed and calculated isochromatic curves. The observations completely verified Stefan's law, and the equations $\lambda_m T = \text{const.}$, and $E_m T^{-5} = \text{const.}$ (E_m being the maximum energy), which are derivable from the general equation of Lummer and Jahnke [see Abstract No. 71 (1901)], viz. :—

$$E = C T^{5-\mu} \lambda^{-\mu} e^{-\frac{c}{(\lambda T)^{\nu}}}$$

Under which appear as special cases the equations of Wien ($\mu = 5$, $\nu = 1$), Thiesen ($\mu = 4{\cdot}5$, $\nu = 1$), and Rayleigh ($\mu = 4$, $\nu = 1$). The general equation with the values $\mu = 4$, $\nu = 1{\cdot}3$ leads to isochromatic curves in satisfactory agreement with observation both for short and long wave-lengths. Moreover, the observations of the authors enabled them to plot for various temperatures the curves $E = f(\lambda)$, which agree fairly well with those obtained from Thiesen's equation, but still better with those derived from the equation, $E = C T \lambda^{-4} e^{-\frac{c}{(\lambda T)^{1{\cdot}3}}}$

A Sylvin-prism was used to obtain the spectrum, and electrically heated

bodies were employed as the source of radiation; in the case of high temperatures the validity of this method was tested by comparative observations. W. E. T.

371. *Radiation of Black Bodies.* **H. Rubens** and **F. Kurlbaum.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 41. pp. 929–941, Oct. 25, 1900.)—If the radiation from a black body be reflected from several surfaces of fluorspar the residual radiation consists of a complex with maxima of intensity for $\lambda = 24\ \mu$ and $\lambda = 31{\cdot}6\ \mu$. By means of a method founded on this property observations were obtained for long wave-lengths and high temperatures which enabled the authors to test the equations of Wien, Thiesen, Rayleigh, Lummer and Jahnke, and Planck. The residual radiation of rock-salt enabled them to examine the wave-length $51{\cdot}2\ \mu$. Temperature measurements were reduced in accordance with the latest determinations of Holborn and Day. The results of the observations are exhibited in curves, which show the invalidity of the equations of Wien, Thiesen, and Rayleigh, but which agree well with that of Lummer and Jahnke, except for extremely low temperatures, and which agree well with the equation of Planck for all temperatures. W. E. T.

372. *Dilatation of Metals.* **L. Holborn** and **A. Day.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 44. pp. 1009–1013, Nov. 8, 1900.)—Tables are given of measurements of the expansion of platinum, palladium, platinum-iridium (80 Pt, 20 Ir), and nickel up to 1000°, of silver to 875°, iron and steel to 750°, and constantan (60 Cu, 40 Ni) to 500°. The expansion of thin half-metre rods of the various metals in electrically heated porcelain tubes is observed through two holes in the tubes. In cases where oxidation takes place small platinum scales are fixed to the rods. With the exception of the magnetic metals the expansion can be accurately expressed as a function of the second degree, as is shown by the close agreement of the calculated and observed values. The expansions per unit of length are formulated as follows :—

Platinum	$(8868t + 1{\cdot}324t^2)10^{-9}$
Palladium	$(11670t + 2{\cdot}187t^2)10^{-9}$
Platinum Iridium	$(8198t + 1{\cdot}418t^2)10^{-9}$
Silver	$(18270t + 4{\cdot}793t^2)10^{-9}$
Nickel	$(13460t + 3{\cdot}315t^2)10^{-9}$
Constantan	$(14810t + 4{\cdot}024t^2)10^{-9}$
Iron	$(11705t + 5{\cdot}254t^2)10^{-9}$
Steel	$(9173t + 8{\cdot}336t^2)10^{-9}$

The formula holds for nickel above 375°, for iron up to 500°, and for steel up to at least 250°. The mean result for platinum varies only by 1 per cent. at 1,000° from the value extrapolated from Benoit's formula, which was deduced from observations made between 0° and 75°. G. E. A.

373. *Entropy and Heat Capacity.* **J. E. Trevor.** (Journ. Phys. Chem. 4. pp. 529–532, June, 1900.)—The author propounds the question, What is the relation between the entropy and the heat capacity of a system with respect to any reversible thermodynamic path?

We have $\eta = \frac{d(\theta\eta)}{d\theta}$, the differentiation being with η constant, and this interprets the entropy η as the increase of the store of heat $(\theta\eta)$ per degree of temperature θ produced from adiabatic work. This point of view is compared

with that of Helmholtz (Ueber die Thermodynamik der chemischen Processen Ges. Abh. 2. 958, 1882).

In the general case the author obtains the equation, $\frac{d(\theta\eta)}{d\theta} = \frac{d'Q}{d\theta} + \eta$, $\frac{d'Q}{d\theta}$ being heat capacity.

The interpretation of this is that a system's entropy, plus its heat capacity with reference to any reversible path, is equal to the change per degree of the system's store of heat $\theta\eta$. The same principle is further illustrated by means of a diagram, showing the Carnot cycles between different values of θ and of η. If $\eta = 0$, $\eta = \eta_a$, $\eta = \eta_b$ be three adiabatics, we find the equation $\frac{d(\theta\eta)}{d\theta} = (\theta + 1)\eta_b - \theta\eta_a$, expressing the work value of the entire series of one degree Carnot cycles between $\eta = 0$ and $\eta = \eta_b$. S. H. B.

374. *Thermodynamical Properties of Steam.* **H. L. Callendar.** (Roy. Soc., Proc. 67. pp. 266–286, Nov. 14, 1900.)—*Assuming* for a vapour the characteristic—

$$v - b = \mathrm{RT}/p - \mathrm{AT}^{-n},$$

and writing V for the ideal volume RT/p and c for the "co-aggregation volume" AT^{-n}, A, R, b, n being constants, we have respectively for the isopiestic and isometric specific heats—

$$\mathrm{S} = \mathrm{S}_0 + n(n+1)\mathrm{R}c/\mathrm{V}$$
$$s = s_0 + n\mathrm{R}\left\{(1 + nc/\mathrm{V})(1 - c/\mathrm{V}) - 1\right\},$$

where S_0, s_0 are functions of T, which are also obviously the specific heats for $p = 0$, $v = \infty$; and we have also—

$$\mathrm{S} - s = \mathrm{R}(1 + nc/\mathrm{V})^2,$$

so that—

$$\mathrm{S}_0 - s_0 = \mathrm{R}.$$

The intrinsic energy is then given by—

$$\mathrm{E} - \mathrm{E}_0 = \int_{\mathrm{T}_0}^{\mathrm{T}}(s_0 - n\mathrm{R})d\mathrm{T} + np(v - b) - np_0(v_0 - b),$$

and the further *assumption* that the kinetic energy of the vapour is proportional to $p(v - b)$ therefore gives $s_0 = n\mathrm{R} = \text{const.}$, and so $\mathrm{S}_0 = (n+1)\mathrm{R} = \text{const.}$, $\gamma_0 \equiv \mathrm{S}_0/s_0 = 1 + n^{-1}$, and consequently—

$$\mathrm{S}/\mathrm{S}_0 = 1 + nc/\mathrm{V}, \quad s/s_0 = (1 + nc/\mathrm{V})(1 - c/\mathrm{V}),$$
$$\gamma \equiv \mathrm{S}/s = \gamma_0/(1 - c/\mathrm{V}),$$
$$\mathrm{E} - \mathrm{E}_0 = n\left\{p(v - b) - p_0(v_0 - b)\right\} = n\left\{\mathrm{R}(\mathrm{T} - \mathrm{T}_0) - (pc - p_0c_0)\right\}.$$

The adiabatics in this case are given by—

$$p^n(v - b)^{n+1} = \text{const.}, \quad p/\mathrm{T}^{n+1} = \text{const.}, \quad (v - b)\mathrm{T}^n = \text{const.},$$

and the entropy by—

$$\phi - \phi_0 = \mathrm{S}_0 \log(\mathrm{T}/\mathrm{T}_0) - \mathrm{R}\log(p/p_0) - n(pc/\mathrm{T} - p_0c_0/\mathrm{T}_0).$$

The latent heat L and the total heat H of the vapour at T are connected with the saturation specific heat of the liquid Σ' by the relation—

$$\mathrm{L} = \mathrm{H} - \int_{\mathrm{T}_0}^{\mathrm{T}}\Sigma' d\mathrm{T},$$

and consideration of a simple cycle gives—

$$\mathrm{H} - \mathrm{H}_0 = \mathrm{S}_0(\mathrm{T} - \mathrm{T}_0) - (n+1)(cp - c_0p_0) - \int_{p_0}^{p}(v' - b)dp,$$

where v' is the volume of the liquid at the saturation-pressure p corresponding to its temperature T, so that—

$$dH/dT = S - \{(n+1)c + v' - b\}\, dp/dT ;$$

hence L is calculable and also the saturation specific heat Σ of the vapour, which is equal to $dH/dT - L/T$.

The last *assumption* made is that for an N-atomic gas $\gamma_0 = 1 + 2/(2N + 1)$, so that for triatomic steam, to which the theory is specially applied, $n = 3{\cdot}5$.

In the case of steam b is taken as 1 c.c., and the experimentally deduced values of V and c at 100° C. under 76 cm. pressure are 1698 and 26·5 c.c. respectively, so that with pressures measured in atmospheres $R = 4{\cdot}552$, $p_1 = 2{\cdot}656 \times 10^{10}$. Further, the calorie being taken as 4·180 joules, the value of R in cal./deg. C. is $4{\cdot}552 \times 1{\cdot}0133 \div 4{\cdot}180 = 0{\cdot}1104$, and thus $S_0 = 0{\cdot}4966$, $s_0 = 0{\cdot}3862$ with the same heat unit. Also Σ' may be taken as $1 + 0{\cdot}00022(T - 333)$ above 60° C., and a recent determination leads to 540·2 as the value of L at 100° C. With these data tables are calculated of the values of c, V, v, c/V, $(c - b)/V$, S, s, γ, H, L, Σ, and other functions for saturated steam at intervals of 10 degrees from 0° to 200° C., the saturation-pressures being experimentally known; and the deviations from Boyle's law are shown by plotting v/V against p, the isothermals on this diagram forming a system of *concurrent straight* lines. Some of the results are given in the following table :—

t	v	S	s	γ	H	L	$-\Sigma$
0°	202602	0·4973	0·3866	1·286	593·5	593·5	1·680
100°	1672·5	0·5236	0·4009	1·306	640·3	540·2	1·028
200°	129·6	0·6399	0·4568	1·401	673·4	471·1	0·759

These numbers differ very greatly from those obtained by Regnault, but agree fairly well with isolated results of later experimenters and with the author's as yet undescribed experiments.

The author then calculates the entropy of water and of steam in the saturated state at the above temperatures, and he also obtains theoretically an equation, equivalent to that of Dupré, which approximately gives the saturation-pressure in terms of the temperature: this he employs to calculate p, and compares his results with Regnault's, which seem to be slightly too small. [The author starts his calculations with these resulting pressures, but the comparison still holds good, as only the small correctional terms are affected.]

[Slight changes have been made in the notation for convenience.] R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

375. *Apparent Mass of the Ions.* **H. A. Lorentz.** (Phys. Zeitschr. 2. pp. 78–79; Discussion, pp. 79–80, Nov. 3, 1900. Paper read before the 72nd Naturforscherversammlung at Aachen.)—From observations on kathode rays has been derived the value of e/m, *i.e.*, of the ratio of the charge of an ion to its mass. But it may be asked, What is to be understood by this mass m? We are compelled to ascribe some mass to an ion, since its motion involves a certain energy in the ether. Let this apparent mass be denoted by m_0. Then $m_0 \leqq m$ and $e/m_0 \geqq e/m$, where $e/m = 10^7$. The ion being supposed a sphere of radius R, it is then calculated that

$$R \geqq \tfrac{2}{3}\, e \times 10^7,$$

but the value of e is, unfortunately, not known. Possible methods of inquiry which might throw light upon the problem were mentioned and discussed.

E. H. B.

376. *Poynting's Theorem.* **P. S. Wedell-Wedellsborg.** (Zeitschr. Phys. Chem. 35. pp. 603–607, Dec. 7, 1900.)—This is a reply to Mie's paper [Abstract No. 2438 (1900)], and consists of a direct attack on Poynting's theorem. According to the author, Poynting and Thomson in their published writings affirm: (1) A constant current in a wire does not produce any charge on or in the conductor. (2) The lines of electric force are, in the neighbourhood of the conductor, parallel to the latter except when it has a statical charge. (3) The tubes of electric force in the field round the current, move so that their direction of motion in the neighbourhood of the conductor is perpendicular to the latter.

On the other hand the author maintains: (1) The constant current always charges the inside and outside of its conductor, the density of charge at a point being proportional to the potential at the point. (2) Hence the lines of electric force are nearly perpendicular to the surface of the conductor, and their angle of inclination changes from point to point, being zero where the potential is zero. (3) The direction of motion of lines of electric force is not perpendicular to the conductor, but parallel to it, and no tubes of force move through the surface of the conductor.

G. E. A.

377, *Magneto-electric Forces.* **H. Lorberg.** (Ann. d. Physik, 3. 3. pp. 522–529, Nov., 1900.)—The author criticises the rival explanations of Pohl's rotation experiment advanced by Lecher [see Abstract No. 94 (1900)] and König [see Abstract No. 2232 (1900)], from the point of view of the old current-element theory. By the principle of the equality of cause and effect, from which it follows that the two couples due to the action between a current-element and a pole are equal and opposite with respect to any assignable axis, and that therefore the two opposite forces go through the same point, and consequently through the current element, Lecher's experiment is very simply explained. The latter has no connection whatever with Pohl's experiment. Lecher is quite right in maintaining that in Pohl's

experiment the cause of the rotation is not to be sought in the axial portion of the current, but in the remainder of the circuit. The same theorem is put down in the author's text-book of Physics. E. E. F.

378. *Electric Pressure.* **J. B. Pomey.** (Écl. Électr. 25. pp. 311–313, Nov. 24, 1900.)—In an electrostatic field, the expression of the components of the pressure along the axes of x, y, and z, at a point where the intensity of the field has components X, Y, and Z, is given by

$$P_x = \frac{k}{8\pi}\{2X(lX + mY + nZ) - l(X^2 + Y^2 + Z^2)\} \qquad (1)$$

and two corresponding equations for P_y and P_z; l, m, and n being the direction cosines of the normal to the surface. This equation may also be put in the form—

$$P_x = \frac{k}{2}(\sigma X + \tau_z Y - \tau_y Z), \qquad (2)$$

if one writes—

$$4\pi\sigma = lX + mY + nZ; \qquad (3)$$

also—

$$\left.\begin{aligned} 4\pi\tau_x &= nY - mZ, \\ 4\pi\tau_y &= lZ - nX, \\ 4\pi\tau_z &= mX - lY, \end{aligned}\right\} \qquad (4)$$

and—

Corresponding equations express P_y and P_z. When thus written, it may be seen that the force P_x, P_y, P_z is half the resultant of two forces. Of these the first, $k\sigma X$, $k\sigma Y$, $k\sigma Z$, is the action which would be exerted by a field of intensity X, Y, Z, upon an imaginary quantity of electricity $k\sigma$. The second force, which has for its components three expressions analogous to $k(\tau_z Y - \tau_y Z)$, is the action which would be exerted by a *magnetic* field of intensity X, Y, Z, on an element of *current* of which the superficial density is $k\tau_x$, $k\tau_y$, $k\tau_z$. The author then proceeds to discuss the existence of this second force.

E. H. B.

379. *Evaporation of an Electrified Liquid.* **W. C. Henderson.** (Phil. Mag. 50. pp. 489–497, Nov., 1900.)—An account is given of experiments made to determine whether a liquid when electrified loses any portion of its charge by evaporation. The loss of charge from an insulated vessel as observed by noting the change of deflection on the scale of a quadrant electrometer was found to be the same whether the vessel was empty or contained a liquid. Experiments were made with water at ordinary temperatures, water heated to near the boiling-point, and with ether which evaporated rapidly at the ordinary temperature of the room. In each case the result was to negative the theory of a loss of charge by evaporation. In the first set of experiments a loss of charge of $0{\cdot}86 \times 10^{-6}$ c.g.s. per second per sq. cm. could have been detected, and in another set with a somewhat modified apparatus the minimum loss of charge which could have been detected was $1{\cdot}06 \times 10^{-6}$ c.g.s. per second per unit area. These results are in opposition to the recently published observations of Pellat. J. J. S.

380. *Air Potentials during Total Eclipse.* **J. Elster.** (Phys. Zeitschr. 2. p. 66–67, Nov. 3, 1900.)—Above Algiers, during last May's eclipse, shortly after totality a decided minimum in the atmospheric potential-gradient was observed. A. D.

DISCHARGE AND OSCILLATIONS.

381. *Retardation of Discharge.* **R. Swyngedauw.** (Journ. de Physique, 9. pp. 487–493, Sept., 1900.)—The author describes his experiments on the discharge of an exciter consisting of two metal balls placed a short distance apart, one being insulated and the other joined to earth. Warburg considered from the results of his experiments that in darkness the retardation of discharge is considerable, and that in ultra-violet light the retardation is diminished. The author comments on Warburg's experiments, and finds from his own that exciters, when carefully *polished* and *placed in an open space*, do not present any retardation of discharge. Warburg's results with ultra-violet light were observed only if the exciter was illuminated during the short time of charge. The author considers that Warburg's experiments confirm the proposition which he formerly stated : Under the action of the ultra-violet rays the lowering of the explosive potential is a function increasing with the velocity of variation of the potential between the poles of the exciter.

J. J. S.

382. *Action of Radiation on the Spark Discharge.* **E. Warburg.** (Deutsch. Phys. Gesell., Verh. 2. 15. pp. 212–217, 1900.)—The author's explanation of the action of radiation on the spark discharge has been opposed by R. Swyngedauw [see preceding Abstract], and in this paper the author again states his views and gives his reasons for disagreeing with Swyngedauw.

The spark apparatus consists of two metal balls A and B ; A joined to earth, B raised to an increasingly high potential. Two cases have to be considered.

I. In the *first case* the potential of B is slowly raised.

(1) When the spark apparatus is exposed to the rays, the retardation which is usually great causes the exact determination of the spark potential to be difficult or impossible.

(2) The passage of the spark takes place under the influence of the rays when the potential reaches a definite value—no retardation is observed. This value is independent of the nature of the radiation.

(3) In some cases the spark potential is a little smaller with than without the radiation ; in other cases this difference changes completely. This difference seems to have no greater meaning than the change which can be observed between the melting- and freezing-point of over-cooled liquids ; and the author considers the values of the spark potential found by spark apparatus exposed to radiation to be the normal values of this magnitude, *i.e.*, values not influenced by passive resistances. According to this explanation in case I. the simple action of the radiation is the raising of the retardation ; a reduction of the spark potential due to the radiation does not take place.

II. In the *second case* there is a different *apparent* behaviour in known cases in which the potential of the electrode B is quickly raised, as, for example, when having been previously connected to earth, it is suddenly joined to the inner coating of a charged jar. It is found in this case under some circumstances that with ultra-violet radiation the spark takes place if the potential of the jar is considerably lower than the spark potential determined in case I.

Swyngedauw explains this phenomenon in conformity with the proposition brought forward by him that by the ultra-violet radiation the spark potential

lowered and the more so the quicker it is raised by the charging up. But is necessary to take into consideration the fact that in these experiments ue spark apparatus becomes charged under damped oscilliations on account d the connection to the jar, on which account the potential difference of the ectrodes from time to time takes a higher value than the potential of the jar. the capacity of the spark apparatus compared with that of the jar can be leglected, and for the first half vibration the damping also, then the maximum otential difference attained is double that of the jar. Hence it is possible hat the lowering of the spark potential recorded by Swyngedauw is only an pparent one, as the potential difference of the electrodes may at times attain value equal to or exceeding the normal spark potential.

The author describes experiments and gives calculations illustrating his iews, and in the result comes to the conclusion that the action of the ultra-iolet rays on the spark discharge consists entirely in a change of the retarda-ion, not in a reduction of the spark potential, whether the potential difference icts for a long or a short time on the spark apparatus. This result stands n complete opposition to the statement of Swyngedauw. J. J. S.

383. *Colour-Rings on Crystalline Plates under Kathode Rays.* **W. B. v. zudnochowski.** (Phys. Zeitschr. 2. pp. 65–66, Nov. 3, 1900.)—Colourless luorspar under the continued action of kathode rays from a concave kathode evelops superficial colours appearing and spreading in the order grey, ellow, orange, brown-yellow, violet, yellow, red, violet. A. D.

384. *Action of the Coherer.* **T. Mizuno.** (Phil. Mag. 50. pp. 445–459, Nov., 1900.)—When a metallic powder is exposed to the influence of electric adiation its resistance changes, and the results of experiment tend to show hat the action of the coherer is correlated in some way to the microscopic parks produced in an assemblage of fine metallic particles in virtue of the ction of electric waves. These sparks may give rise to a "welding" action ith the consequent formation of conducting-chains of particles and lessening f the resistance of the coherer.

The author made a series of experiments on a number of metals, some lloys, and their mixtures. The source of electric waves was a Hertzian arabolic vibrator, emitting electric waves of about 60 cm. wave-length. he coherer consisted of a glass tube about 5 cm. long, 5 mm. in diameter, aving two movable and finely adjustable small pistons, between which the etallic powder could be introduced. From the extremities of the pistons ires were led to the arms of a Wheatstone's bridge. The galvanometer used as a Kelvin's astatic double-coil one. The bridge-current was supplied by a ingle Daniell cell, the resistance, ranging between 1,000 and 2,000 ohms, eing always inserted in the circuit before the current entered the arms of he bridge. This precaution was necessary because when the current xceeded a certain strength the resistance of the coherer often underwent ery marked spontaneous fluctuations during the repeated processes for alancing the bridge. The author studied the history of the successive hanges of the resistance of the coherer accompanying successive oscillating parks of the Hertzian vibrator, and gives his results in tables and diagrams. He sums up the chief results obtained as follows :—

(1) In platinum, lead, nickel, aluminium, cadmium, copper, steel, silver nd potassium coherers, the action of electric waves is to reduce their esistances at first to a large extent, and then this reduction continues, though

with some intermediate rise and fall, until the resistances assume certain final values.

(2) In the case of iron, tin, bismuth, zinc, and antimony coherers, their resistances are diminished at first, but soon afterwards the changes become very irregular, the diminution and increase occurring at random. With the iron coherer the action is conspicuously irregular.

(3) With one and also two small lead-ball coherers the resistance attains its final value very rapidly, so that the successive stages of their histories present nothing conspicuous.

(4) In the alloys, namely German-silver, brass, electric fuse, ordinary solder, Rose's and Wood's metals, the general tendency is to the reduction of their resistances to certain limiting values, though with more or less irregularity.

(5) In the case of the coherers with the mixed metals, namely, iron with silver, cadmium, Rose's and Wood's metals respectively, and also silver with Wood's metal, the mode of change of resistance seems to be chiefly governed by the percentage ratios of the constituents. The history of each coherer presents the character which would belong to the predominating constituent.

(6) With zinc, lead, potassium, and electric fuse, the resistance suddenly assumes infinite value at a certain stage during the experiment.

The results appear to support the view that the action of the coherer may be due to something like welding taking place on a small scale among fine metallic particles in consequence of the induced microscopic sparks. The lowering of resistance seems to be greatly determined by the melting-point of each metal and alloy, the lower the melting-point the greater being the reduction. This reduction also evidently depends upon the specific electric conductivity. J. J. S.

385. *Coherers and Decoherence.* **G. Ferrié.** (Ecl. Électr. 24. pp. 499–503, Sept. 29, 1900. Paper read before the International Electrical Congress at Paris.)—The writer extends the experiments of Hughes, Lodge, Tommasina, Popoff, and Branly, using coherers of carbon-carbon, carbon-metal, metal-metal, metal-liquid, in air, oil, and vacuum respectively. Carbon-carbon is comparatively less sensitive than the other combinations; the coherence is of unstable resistance, but tends to persist. Carbon-metal gives more certain contact, and contact may conveniently be restricted to a single point; the best results were obtained from polished granules of carbon 0·5 mm. diameter, in a glass tube provided with metallic electrodes, of Pt, Au, Ag, Ni, Cu, Zn, &c. The results with metals were always better than when using carbon electrodes. In general, the most effective coherer is one having a resistance of from 1,000 to 25,000 ohms, working with a current less than a milliampere. If the initial resistance is too high, the effects are feeble and generally disappear. If the resistance is too low, the effects at first may be striking, but they may suddenly cease. If the initial resistance is infinite, the action is irregular; the strong impulse necessary for coherence will probably cause persistent contact. Zinc and its alloys give the greatest sensitiveness. Nickel and platinum give the most regular results. The degree of oxidation has great influence on the sensitiveness. For different metals the distance between the coherer and the oscillator appears to have different effects. With zinc, the sensitiveness over a long range is fairly constant, and then ceases abruptly. Nickel-carbon and platinum-carbon are comparatively very sensitive at the longer distances. Coherence and decoherence effects can be obtained between liquids and

metal; the best results were with acidulated water and a dipping wire touching just at the surface. Copper, which is attacked by the acid, gives better effects than platinum. Carbon-metal, and metal-metal in petroleum behave as in air—if anything, the arrangement is slightly less sensitive in petroleum. The vacuum experiments were inconclusive, owing to air arms. The paper concludes with a speculation as to the action of coherence and decoherence. R. A.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

386. *Electrocapillarity.* **Gouy.** (Comptes Rendus, 131. pp. 835–837, Nov. 19, 1900.)—It appears that in a capillary electrometer there is at the mercurial surface an elective action which produces an accumulation of anions of some salts in preference to those of a less active or an inert salt (iodides rather than bromides for example). The state of final equilibrium between the ions is broken when the surface is varied, and is restored more slowly the slower the active anions in proportion to the others: and this is the cause of electrocapillary viscosity. A. D.

387. *Conductivity of Gases when Carrying Electric Discharges.* **J. Stark.** (Ann. d. Physik, 3. 3. pp. 492–512, Nov., 1900.)—This paper contains a summary of all the papers which have been published on the measurement of the conductivities of the gas at the different parts of a vacuum tube carrying an electric discharge. The general method adopted for determining the conductivity consists in measuring the difference of potential and the electric current between two small subsidiary wire electrodes. These are placed on an equipotential surface of the main discharge and are joined in circuit with a small electromotive force. The theory of the method is considered in the present paper. The general conclusions arrived at are: (1) The strength of the cross current is independent of the potential gradient of the main discharge, and it gives an approximate value of the conductivity of the gases at the position of the transverse electrodes. (2) The conductivity in gases carrying a discharge varies from place to place; it is, as a rule, greater in the luminous parts than in the neighbouring dark spaces. (3) The variation of conductivity from place to place does not correspond everywhere to the variation of the potential gradient. This is explained by the presence of internal differences of potential (C) Owing to the ionising action of the charged particles the conductivity of a gas increases with the current strength. (5) The electric current also alters the concentration of the ions and consequently the conductivity, by the variation of the strengths of the positive and negative currents from place to place. J. B. H.

388. *Thermo-elements for the Measurement of High Temperatures.* **S. Lindeck** and **R. Rothe.** (Zeitschr. Instrumentenk. 20. pp. 285–299, Oct., 1900.)—Details are given of the methods of testing thermoelectric apparatus for the measurement of high temperatures as carried out at the Reichsanstalt at Berlin. The first part of the paper describes the furnaces used and the arrangement of the junctions in them. In later experiments the thermo-elements of Le Chatelier's form were compared in electrically heated furnaces, constructed as described by Holborn and Day, which consist of several concentric tubes, the inner tube containing the thermo-electric junction and the tube next it the wire whose rise of temperature on the passage of a current causes the heating of the furnace. These tubes are formed of a highly infusible

sort of porcelain. For temperatures up to 1,400° the material used for the heating-wire is nickel. For higher temperatures up to 1,600° and 1,700° platinum-iridium is used.

The second part of the paper gives full particulars of the method of measurement of the e.m.f. by a compensation arrangement. J. J. S.

389. *New Measuring Instruments of Siemens and Halske.* **A. Franke.** (Elektrotechn. Zeitschr. 21. pp. 891–894, Oct. 25, 1900.)—The first two of these instruments are developments of the wattmeter for use with both alternating and continuous currents described in the Elektrotechn. Ztschr. 20. pp. 665–670, September 14, 1899 [see Abstract No. 176 (1900)]. The main points of difference between this wattmeter and the ammeter or voltmeter are first discussed, viz.: In the latter, the influence of eddy-currents is not so deleterious since the difference of phase of the currents in the fixed and movable coils (which are connected in series) is zero in the voltmeter, and can be made zero or very nearly zero in the ammeter. The instrument can thus be made of metal with the exception of the bobbins. The second difference is that the deflections do not follow a straight-line law; an open scale is however obtained when about 0·2 to 0·25 of the range is passed. In the voltmeter, by making, for example, 0·1 of the resistance of copper, and the rest of manganin wire, the temperature coefficient of the instrument can be made less than a tenth of the temperature coefficient of the copper and can thus be neglected for practical purposes. Since the self-induction of the whole system only varies between 0·038 and 0·054 henry from one end to the other of the scale, with a resistance of 800 ohms, the difference between the apparent and the ohmic resistance is less than $\frac{1}{10}$ per cent. at 100 periods per second, and no correction is required for self-induction. By removing a plug the range of the instrument can be doubled. In the ammeter the fixed and movable coils are connected in parallel, so as to enable the current in the movable coil to be less than that in the fixed coil. Inductionless resistance, which does not vary with temperature, is arranged in each of the circuits, so as to reduce the temperature coefficient of the instrument to a quarter of that of the copper. The difference between the readings with direct currents and with alternating currents of 100 periods per second is less than $\frac{1}{10}$ per cent. The range can be increased by inserting a resistance in the circuit carrying the stronger current (*i.e.*, the fixed coil circuit). The instrument consumes 40 watts at its maximum deflection.

Some portable direct-current Deprez-d'Arsonval-pattern instruments are also described. In these instruments the movable coil is stretched between two metal bands which serve to centre it and also to provide the directive force. The whole movable system, including a light aluminium pointer, only weighs 0·6 gramme. The damping of these instruments is effected in two ways, viz.: By a shunt to the movable coil where the sensitiveness is greater than is required; and by a closed circuit on the movable coil itself. It has a sensitiveness of 15.10^{-6} ampere per division. Various forms of this instrument are described with photographic illustrations. C. K. F.

390. *Modified Wehnelt Interrupter.* **J. v. Pallich.** (Ann. d. Physik, 3. pp. 543–544, Nov., 1900. From the Akademische Anzeiger d. K. Akad. d. Wissensch. zu Wien, xii. Sitzung vom 3 Mai, 1900.)—The author describes a form of Wehnelt interrupter in which the lead plate is replaced by a copper wire, and the platinum anode by a steel wire. Both wires are enclosed in glass tubes, that containing the steel wire being strong, and tightly surrounding

ıe steel tip. Both wires dip into dilute sulphuric acid. The steel wire is ı mm. or 2 mm. thick, and its upper end is held in a cork provided with a cup ɔr a mercury contact. The vessel containing the sulphuric acid is surrounded ɔy cold water to keep the temperature down. The two glass tubes with their ɔires are inserted in a rubber stopper provided with holes to allow the acid to ɔw back into the bottle in case it spurts out. A curious phenomenon noticed ı the working of the instrument is that the steel wears away just where the ɔire emerges from the glass tube, and not in the portion more immersed in ıe acid. A constriction is thus formed, and the effect appears to be that its ɔrmation assists rather than retards the generation of the gaseous layer, the xplosions becoming stronger and more abrupt as the work of the interrupter ontinues. The double adjustment possible in this type of instrument makes particularly easy to obtain the necessary current strength. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

391. *Experimental Tracing of E.M.F. and Current Waves in the Rotors of Induction Motors.* **H. Rupp.** (Elektrotechn. Zeitschr. 21. pp. 820–822, Oct. 4, 1900.)—To render the ordinary Joubert-contact methods applicable to he rotor currents of an induction motor, it becomes necessary to drive the ontact-disc at a speed corresponding to the slip of the rotor. One way of oing this is to connect the stator circuits of a synchronous motor to the rotor ircuits of the motor under investigation; the rotor of the synchronous motor, vhich carries the contact-disc, being polarised by a suitable continuous urrent fed into it by means of slip-rings. Under these conditions, however, he induction motor does not run as under normal conditions of working, the ounter-e.m.f. of the synchronous stator reacting on the rotor of the induction notor. An arrangement which more nearly conforms to the practical con- litions of working is that in which the rotor circuits are closed through the tarting resistance, the stator of the synchronous motor being coupled in arallel with the starting resistance. Another device described by the author onsists of an auxiliary motor which rotates synchronously with the stator ield of the motor under investigation, whose rotor is placed in line with that f the auxiliary motor. On the shaft of the auxiliary motor is mounted a disc arrying a couple of brushes placed side by side but insulated from each ther and connected to two slip-rings. These brushes bear on the inner urface of a ring of fibre attached to the pulley of the induction motor and rovided with a strip of metal which momentarily connects the brushes as it asses under them. The slip-rings in connection with the brushes are placed n circuit with a condenser and joined across the brushes of the rotor of the nduction motor. The circuit will be periodically closed for a certain relative osition of the stator field and the rotor. In order to vary this position, and o obtain a number of points on the curve, the stator of the auxiliary syn- hronous motor may be made movable round the rotor shaft. The same ffect may be produced electrically, by altering the phase of the stator field vithout any mechanical rotation, as follows: A second auxiliary induction notor has a rotor provided with an index moving over a scale and capable of eing clamped in any required position; the adjustable rotor is connected cross the supply mains, while the currents induced in the stator windings of his auxiliary motor are used for supplying the stator windings of the auxiliary ynchronous motor. Changing the position of the fixed rotor is obviously quivalent to a rotation of the stator of the synchronous motor. The author

gives a number of curves obtained by the methods described; the curves appear to differ very little from the pure sine form. A. H

392. *Magnetic Deposits formed in a Magnetic Field.* **C. Maurain.** (Comptes Rendus, 131. pp. 880–881, Nov. 26, 1900.)—In continuation of his former work [see Abstract No. 2235 (1900)], the author gives the results of a comparison of (1) the magnetisation of an electrolytic deposit of iron formed in a magnetic field of given strength with (2) that which a similar deposit, not formed in a magnetic field, acquires when afterwards subjected to a field increasing from zero to the strength of the preceding field. The electrolytic bath employed consisted of ammonium oxalate and double oxalate of iron and ammonium, the magnetisation of the deposits obtained being more regular and more intense than with those formed by the pyrophosphate bath formerly used. In case (1), the curve with the values of I as ordinates and those of H as abscissæ is very steep, the value of I/H being at first very great, and only diminishing when a strength of field of about 10 gausses is attained; this curve has no point of inflexion such as occurs in the ordinary curve of case (2). T. H. P

393. *Hadfield's Nickel-Manganese Steel.* **E. Wilson.** (Electrician, 46 pp. 85–86, Nov. 9, 1900.)—The sample contained Ni 25, Mn 5·04, and C 0·8 per cent. It was found to be practically non-magnetic. The specific resistance is $88{\cdot}3 \times 10^{-6}$, and the temperature coefficient 0.088 per cent. per 1° C. W. H. E

394. *Currents and Voltages in Polyphase Systems.* **C. E. Guye.** (Comptes Rendus, 130. pp. 1382–1383, May 21, 1900.)—The problem of finding the voltages and currents when the polyphase mains possess capacity and are affected by mutual and self-induction is solved analytically. It is shown that the problem can be reduced to that of a single-phase main which possesses self-inductance L′, and capacity K′ per unit length where L′ and K′ are determined by the equations—

$$L' = L_{1\cdot1} + 2L_{1\cdot2}\cos\frac{2\pi}{n} + 2L_{1\cdot3}\cos\frac{4\pi}{n} + \ldots$$

in which $L_{1\cdot1}$ is the self-inductance of the main, and $L_{1\cdot2}$ the mutual inductance between the mains 1 and 2, &c.; and—

$$K' = K_{1\cdot1} + 2K_{1\cdot2}\cos\frac{2\pi}{n} + 2K_{1\cdot3}\cos\frac{4\pi}{n} + \ldots$$

These equations enable us to solve the problem of finding the voltages and currents when they have attained their steady state. [See also Abstracts Nos. 1308 and 1868 (1900).] A. R.

MEDICAL ELECTRICITY.

395. *The Law of Dubois-Reymond and Measurements in Electro-biology.* **Dubois.** (Revue Int. d'Électrothérapie, 10. pp. 230–238, Aug., 1900. Paper read before the International Congress of Electro-biology at Paris, 1900.)—Inasmuch as the phenomena of muscular contraction can be produced equally well by battery currents or by discharge from an induction coil, a static machine, or a condenser, there is probably some condition common to all these modes of stimulation.

Experiments with condenser discharges show that as the charging potential is increased the required capacity of the condenser decreases rapidly; for example, the minimal contraction in the muscles of man is obtained with a capacity of 0·48 microfarads charged at 12·6 volts, with 0·017 at 35 volts, and with 0·007 at 70 volts, the capacity in the last example being seventy times less than in the first, while the potential is only six times greater. In man a minimum potential of about 12 volts is necessary, and discharges at lower potentials are ineffective, whatever the capacity of the condenser. If the energy of the condenser discharges be calculated, it appears that at low potentials it is relatively large; that as the potential is raised and the capacity is diminished the energy required becomes less until a point is reached, after which it again increases; there is a relation between potential and capacity such that a point can be found at which the minimal contraction is produced with a minimum expenditure of energy. Energy is wasted in the case of the large condenser at low potential because much of the discharge is below the effective minimum of 12 volts; while in the case of a small condenser and a high potential there is waste because the duration of the discharge is too short. In the case of a large capacity and a low potential, the rate of discharge may also be too gradual to be effective owing to the resistance of the patient's skin. The view of Dubois-Reymond that the effect on a muscle varies simply with the magnitude and rate of change of the stimulating current holds good to a modified extent only. The discharge of a Tesla coil fails because the individual impulses of which it is made up have too short a duration. H. L. J.

396. *Dependence of Therapeutic Effects on Frequency.* **G. Gautier** and **L. Larat.** (Revue Int. d'Électrothérapie, 10. pp. 225–227, Aug., 1900.)—The authors have compared the therapeutic effects of sinusoidal currents of ordinary (low) periodicities with those of the high-frequency apparatus of Tesla and d'Arsonval. They consider that the former are the more effective in promoting general nutrition and in correcting defective nutrition, but they regard the latter as being more suitable for the treatment of certain cutaneous affections. H. L. J.

397. *Phototherapy in Surgery.* **A. V. Minine.** (Revue Int. d'Électrothérapie, 10. pp. 193–204, July, 1900.)—The author finds that good results have followed from the application of light for the relief of pain. He uses an incandescent lamp of 50 candle-power (or 16 c.p. in some cases) with a reflector, and the lamp is held near to the painful part for ten or fifteen minutes every day or every other day. Its application markedly reduces the pains and the swellings of rheumatism, of bruises and of inflamed parts. In neuralgias it may at first increase the pain, but the after effect is good. Five cases are reported. H. L. J.

398. *Electrical Treatment for Pulmonary Tubercle.* **H. Guimbail.** (Revue Int. d'Électrothérapie, 10. pp. 248–252, Aug., 1900. Paper read before the Société Médicale de Monaco, March 24, 1900.)—The author has successfully treated a case of pulmonary tuberculosis by statical applications to the affected part; two metal plates were used, one on the chest and the other on the back. They were of the size of a five-shilling piece, and the discharge was passed between them through the chest. The patient gained in weight and lost his symptoms. H. L. J.

399. *Electrical Treatment of Tuberculosis.* **Jacquin.** (Revue Int. d'Électrothérapie, 10. pp. 252–253, Aug., 1900.)—The author treated a case of confirmed pulmonary disease by sparks from a statical machine applied to the region of the chest over the affected area of the lung. There were two applications of ten minutes daily for three months, followed by one application daily for three months more. Treatment was begun in March, 1898. The case still continued in good health at the date of the paper. H. L. J.

400. *Electrical Treatment of Fibroma.* **A. Zimmern.** (Archives d'Él. Médicale, 8. pp. 481–501, Oct., 1900.)—A review of the treatment of uterine fibroma by electricity. After describing in detail the method of procedure the author concludes by saying that the current probably acts by causing a cicatricial condition of the lining of the uterus, by setting up contractions in the muscular tissue of the organ, and by causing coagulation of the blood in the vessels. He regards the method as a good one. The paper itself is not suitable for a brief abstract, and should be referred to. H. L. J.

401. *Voltmeter or Milliammeter in Exploring the Excitability of Nerve and Muscle.* **E. Huet.** (Archives d'Él. Médicale, 8. pp. 433–448, Sept., 1900.)—In testing the excitability of muscles two methods have been advocated, the one by a comparison of the minimum currents required to provoke contractions, and the other by a comparison of the minimum e.m.f.'s needed to produce them. It has been shown by Dubois (of Berne) that the presence of self-induction in the testing circuit, by retarding the rise of current after closing the circuit, affects the magnitude of the current needed for producing a contraction ; but on the other hand a comparison of e.m.f.'s may also give a wrong impression because of the great variations in the resistance of the skin of different parts of the body. He shows that when the same case is tested on successive days the variations in the e.m.f.'s are much more irregular than those of the milliamperes ; and that a thorough moistening of the skin will cause a much greater change in the e.m.f.'s than in the currents required to produce the minimal contractions. He therefore prefers the milliampere readings to the readings of the voltmeter, but when great accuracy is needed he would make comparisons by both methods. H. L. J.

REFERENCES.

402. *Electrical Units and Standards.* (Amer. Inst. Elect. Engin., Trans. 17. p. 609 ; Discussion, pp. 610–618, Nov., 1900.)—Report of Kennelly's Committee on the subject, together with the discussion thereon.

403. *Inductance of Concentric Cables.* **W. H. Everett.** (Elect. Rev. 47. pp. 731–732, Nov. 9, 1900.)—The author gives formulæ for calculating the inductance of concentric and triple-concentric cables, both for three-wire and three-phase circuits, and gives some practical examples showing the loss of volts due to this inductance. G. H. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

404. *Molecular Constitution of Water.* **W. Sutherland.** (Phil. Mag. 50. p. 460–489, Nov., 1900.)—The author discusses the physical properties of water and their bearing on its molecular constitution, and comes to the following conclusions: Ordinary water-vapour being H_2O, which it is proposed to call internationally hydrol, ice is trihydrol $(H_2O)_3$, and water a mixture of trihydrol and dihydrol $(H_2O)_2$, in proportions depending upon the temperature. Probably at its critical temperature water is practically pure dihydrol. The latent heat of fusion of ice is not an ordinary physical latent heat of fusion, but is mostly a latent heat of dissociation of trihydrol into dihydrol, partly masked by heat of solution of trihydrol in dihydrol. The latent heat of evaporation of water includes also the heat of dissociation of the dihydrol and trihydrol of water into the hydrol of steam. The specific heat of water is not an ordinary specific heat, but includes a certain amount of heat of dissociation. Pressure dissociates trihydrol. J. J. S.

405. *Velocity of Solution of Solid Substances.* **L. Bruner** and **S. Tolloczko.** (Zeitschr. Phys. Chem. 35. pp. 283–290, Nov. 2, 1900. Paper read before the Versammlung Polnischer Naturforscher u. Aerzte at Krakau, June 24, 1900.)—It was shown by Noyes and Whitney in 1897 that the velocity of solution of lead chloride and benzoic acid followed the logarithmic law, according to the formula $dx/dt = K(C - x)$, where C is the concentration of the saturated solution, x the concentration at the time t, and K a constant. The authors have experimented with a number of other substances—gypsum, acetanilide, phenylacetic acid, phenylpropionic acid, and benzoic acid—a definite quantity of each being fused, cast into a regular form of known surface, and attached to a mechanical stirrer immersed in water at a constant temperature. Portions of the solution were withdrawn from time to time and the concentration determined. The formula given above is confirmed, and, in addition, the value of the constant per square centimetre of surface has been determined. The system, solid substance—unsaturated solution, is considered to be practically unrealisable, and the solid substance is regarded as being in contact with a layer of saturated solution from which diffusion takes place into the surrounding liquid. The constants found are therefore diffusion constants, and the method described affords a convenient method for the determination of the diffusion constants of substances which are soluble with difficulty. N. L.

406. *Solubility of Manganous Sulphate.* **F. G. Cottrell.** (Journ. Phys. Chem. 4. pp. 637–656, Nov., 1900.)—The solubilities of the hydrates with 1, 4, 5, and 7 molecules of water of crystallisation have been determined. The author points out errors in Linebarger's work on the same subject, and shows that the above system offers no singularities. Attention is, however, drawn to the slowness with which systems containing the monohydrate as solid phase attain equilibrium. F. G. D.

407. *Berthier's Method for Determining the Calorific Value of Fuels.* **U. Antony** and **E. di Nola.** (Rivista Sci. Industriale, 32. pp. 222–223, Oct. 10,

and 226–229, Oct. 20, 1900. From the Gazzetta Chimica Italiana.)—Tw common objections to Berthier's method of measuring the calorific value c fuels, in which the lead obtained on heating the fuel with litharge is weighec are (1) that volatile products are evolved at temperatures lower than that a which reduction of the litharge takes place, and (2) that the heats o combustion of the different elements of the fuel are not proportional to th amounts of oxygen which they take up on burning. From a number of trial with different kinds of coal, the authors conclude that, if care is taken to hea the mixture of fuel and litharge slowly, reduction of the latter occurs withou the evolution of any volatile matter. In the case of ordinary fuels, the erro introduced into the calculation of calorific power by assuming that all th lead obtained is due to carbon is very small and may be neglected. Th available hydrogen in a fuel may be measured by heating it in a graphit crucible with lead fluoride, the reduction of which to metal is due entirely t the hydrogen. If p_C is the quantity of lead obtained by the reduction o litharge, and p_H that formed from the fluoride, the calorific power of the fue in calories is given by the formula—

$$P = \frac{p_C}{34{\cdot}5} \times 8083 + \frac{p_H}{103{\cdot}5} \times 29367.$$

T. H. P

408. *Coagulation of Turbid Media.* **W. Spring.** (Archives des Science 10. pp. 305–321, Oct., 1900. *Résumé* of a paper in the Bulletin de l'Académi de Belgique, July, 1900.)—The author describes experiments on the coagulatio ("flocculation") of water containing finely divided resin, &c., in suspension, b means of salts and acids, from which he draws the following conclusions (1) Solutions of salts which cannot be obtained in an optically clear conditio (*état optiquement vide*), *i.e.*, those which are hydrolysed by water, possess th power of coagulating such turbid solutions in a very high degree; thi depends partly on the high agglutinative action of the metallic hydroxid produced on hydrolysis of the salt, and partly on the powerful flocculating power of the acid. (2) Coagulation cannot be brought about by those electri actions which produce discharge at a distance or create an electric field b influence; the action is therefore of a kind different from that involved in th precipitation of dust or smoke from the air. (3) Any electric current, n matter how feeble, produces flocculation which proceeds quicker as th current intensity increases. (4) Electrolytes of the same conductivity an containing the same kation bring about flocculation of the same solution i the same period of time. When the kations are different the speeds o coagulation are in the same order as the velocities of the kations. (5) Th nature of the anions seems to play a secondary or even a negligible part i this phenomenon. T. H. P

409. *Heat of Combustion of very Volatile Liquids.* **Berthelot** an **Delépine.** (Annal. Chim. Phys. 21. pp. 289–296, Nov., 1900.)—Th determination of the heat of combustion of volatile liquids in the calori metric bomb is subject to errors caused by the partial volatilisation of th substance or by its slow oxidation by the compressed oxygen. In such case he liquid is enclosed in a sealed glass bulb, which is broken at the desire moment by the explosion, effected by electrical means, of a weighed quantit of a mixture of camphor and guncotton. The calorimetric value of the latte is previously determined and the corresponding correction made. Th molecular heats of combustion of a number of volatile liquids have bee determined by this process with the following results: Acetaldehyde, 278·8

al. ; methylal, 461·9 cal. ; methyl formate, 233·2 cal. ; ethyl formate, 391·4 al. ; propionaldehyde, 433·8 cal. ; acetone, 426·3 cal. N. L.

410. *Combustion of Gases.* **S. Tanatar.** (Zeitschr. Phys. Chem. 35. pp. 10–342, Nov. 2, 1900.)—Bunsen explains the influence of dilution with neutral gases in preventing the explosion of gaseous mixtures as due to the lowering of the temperature of combustion below the ignition-point. This explanation cannot be given in the case of mixtures of $2H_2 + O_2$ (produced by electrolysis) with hydrocarbons. A mixture of hydrogen and oxygen in equivalent proportions becomes non-explosive when only 11–12 per cent. of propylene is added, and a similar effect is produced by the isomeric trimethylene. The hydrogen of the explosive mixture remains unburnt, and no large amount of carbon dioxide is produced, the products of combustion being carbon monoxide and water ; the mixture becomes explosive when the proportion of oxygen to propylene rises to that required by the reaction $C_3H_6 + 3O_2 = 3CO + 3H_2O$. Less heat is developed in this change than would be produced by the combustion of the hydrogen which is also present in the gaseous mixture, and it is suggested that the deciding factor is not the total heat of combustion, but the reaction velocity.

A precisely similar effect is produced by marsh gas, of which 22–24 per cent. suffices to prevent the explosion of a mixture of equivalent quantities of hydrogen and oxygen. Here again the explosion takes place when the proportion of oxygen is sufficient to burn the marsh gas to water and carbon monoxide—$2CH_4 + 5O_2 = 2CO + 4H_2O$. T. M. L.

411. *Lecture Experiments to Illustrate Equilibrium and Dissociation.* **J. Stieglitz.** (Chem. News, 82. pp. 212–213, Nov. 2, 1900. From the Amer. Chem. Journ. 23, No. 5.)—The effect of an excess of one of the decomposition products in repressing dissociation may be shown by sealing up phosphorus trichloride or phosphorus tribromide with bromine, under reduced pressure, using (1) molecular proportions and (2) a large excess of the phosphorus compound. When the tribromide tubes are heated to 80–90°, and the trichloride tubes to 40–55°, the difference of colour is very marked in the two pairs of tubes. The difference in the dissociation constants of PBr_5 and PCl_3Br_2 is shown by the difference in colour at 50° of the two tubes containing molecular proportions of the reagents.

The repression of the dissociation of ammonium hydroxide by an ammonium salt can be shown by adding ammonium chloride solution to one of two beakers of water containing phenol phthalein made bright red by the addition of a little dilute ammonia ; the addition of the ammonium chloride causes the colour to fade to a pale pink. Ammonium chloride may have an acid reaction, but the experiment can also be shown with an ammonium chloride solution that has been made faintly *alkaline* to phenol phthalein by the addition of ammonia. A corresponding experiment is described for the repression of the dissociation of acetic acid by sodium acetate ; the intense red of a methyl orange solution acidified with acetic acid is turned to a reddish brown neutral tint by adding a neutral (or very feebly acid) solution of sodium acetate. T. M. L.

412. *Diagram of Freezing-Point Depressions for Electrolytes.* **J. G. MacGregor.** (Nova Scotian Inst., Trans. 10. pp. 211–234, 1900.)—For solutions, a curve comparable to the curves connecting pv and v for gases can

be obtained by plotting the depression of the freezing-point per equivalent of dissolved substance against the dilution. In the case of electrolytes it is better to use, in place of the dilution, the ionisation coefficient deduced from conductivity measurements. The form of the curves will then depend (1) on the depression constant, (2) on the number of equivalents in the molecule, and (3) the number of ions produced from each molecule; and of these (2) and (3) may vary with the concentration. Curves of this kind are given for KCl, NaCl, HCl, AmCl, KNO_3, HNO_3, KOH, $BaCl_2$, K_2SO_4, Na_2SO_4, H_2SO_4, Na_2CO_3, $MgSO_4$, and H_3PO_4. The conclusions drawn are: (1) That the curves are compatible with the van't Hoff-Arrhenius theory of the depression of the freezing-point of electrolytes; (2) that all electrolytes have the same depression-constant, the value being 1·85, and the error probably not greater than 0·01; and (3) that in some cases the degree of association and method of dissociation of the dissolved substance can be ascertained from the curves.

T. M. L.

413. *Cryoscopic Researches.* **P. Chroustchoff.** (Comptes Rendus, 131, pp. 883–886, Nov. 26, 1900.)—The depression of the freezing-point is measured by a platinum resistance thermometer, and the concentration of the solution is determined by analysis after the freezing-point has been reached. Values are given for aqueous solutions of sodium chloride, potassium bromide and sulphate, and cane-sugar. Temperature measurements are given to 0·0001°.

T. M. L.

414. *Electrode Potentials.* **W. Nernst.** (Zeitschr. Elektrochem. 7. pp. 253–255; Discussion, pp. 255–257, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—In this paper an account is given of some experiments and calculations by Wilsmore, details of which will shortly be published. The theoretical and practical advantages of the hydrogen electrode as a standard of comparison are emphasised, and a table is given of the potentials of a number of electrodes, some experimentally determined, but chiefly collated from various sources. The p.d. between the hydrogen electrode and Ostwald's calomel electrode is found to be 0·283 volt.

The Discussion, in which **Hittorf**, **Bredig**, and **W. Nernst** took part, turned on the influence, on the potential, of differences in the chemical behaviour or stage of oxidation of such metals as copper, chromium, and iron.

N. L.

415. *Potential of Silver in Mixtures of Silver Bromide and Sulphocyanide.* **A. Thiel.** (Zeitschr. Elektrochem. 7. pp. 305–307, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—The potential of silver in contact with a mixture of slightly soluble silver salts depends on the solubility of the mixture. If the salts are not isomorphous the solubility, and therefore the potential, will be independent of the composition of the mixture. If they form a continuous series of isomorphous mixtures the solubility curve will be continuous, as in the case of silver chloride and silver bromide, but may show a maximum or minimum. If the isomorphism is not complete, the solubility curve will show a horizontal line connecting two curves, and this line may represent either an intermediate solubility or a maximum or minimum. The former type has been found in the case of silver bromide and iodide, and an example of partially miscible salts which show a

rizontal line of maximum solubility is now given in the case of silver omide and sulphocyanide. T. M. L.

416. *Normal Electrodes and the Absolute Potential of Metals.* **W. stwald.** (Zeitschr. Phys. Chem. 35. pp. 333–339, Nov. 2, 1900.)—The e of a hydrogen-electrode as standard in place of calomel and decinormal otassium chloride has the disadvantage that such an electrode is far more oublesome to set up; but the chief disadvantage is that the acid (or alkali) hich must be used introduces two ions which differ enormously in their locity of migration, and so must necessarily set up a potential difference hen brought into contact with other solutions; this source of error is a inimum in the case of potassium chloride, the ions of which have almost actly the same velocity of migration. The hydrogen-electrode has also the sadvantage of a large pressure coefficient (0·029 volt per atmosphere), hich would be affected by the vapour pressure of the solution, and the mperature coefficient, though small, is not accurately known. T. M. L.

417. *Conductivities of Solutions of Alkaline Iodates, and the Calculation of onductivities.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 44. p. 1002–1008, Nov. 8, 1900.)—Tables embodying the results of very exact easurements of the equivalent conductivities of aqueous solutions of the lorides, nitrates, and iodates of potassium, sodium, and lithium, from 0·0001 0·002-normal. Likewise tables of the mobilities of the six ions, showing eir variation (decrease) with increasing concentration. Denoting by α the egree of dissociation as calculated from the conductivities, the author shows at the data are very exactly given by the formula $\frac{1-\alpha}{\alpha^p} = Bm^{\frac{1}{2}}$, where m = equivalent concentration, and p and B are constants.

[A very similar suggestion has been already made by Bancroft.]

F. G. D.

418. *Thermic Pressure and the Theory of Solutions.* **G. N. Lewis.** (Zeitschr. Phys. Chem. 35. pp. 343–368, Nov. 2, 1900.)—Thermodynamical rguments are given in support of the equation, $dP_1/dP_2 = \sigma_2/\sigma_1$, in which P_1 nd P_2 denote the (different) pressures to which two solid or liquid phases of ne and the same substance are subjected, these phases being in equilibrium ith each other through the medium of another phase; while σ_1 and σ_2 lenote the specific volumes. These considerations lead up to the introduction f a function ψ, styled the "Transition-tendency," satisfying the partial ifferential equation $\frac{\partial\psi}{\partial P} = k\sigma$.

"Thermic pressure," denoted by β, is defined as the "pressure" on either ide of an imaginary plane drawn within the mass of a phase, and the author rites $\beta - \alpha = P$, where $P \doteq$ external (equilibrium) pressure, and $\alpha =$ the 'Attraction-pressure." Considering a system made up of a liquid or solid hase and the corresponding vapour, it is proved from the fundamental quation that the fractional change in the vapour pressure is equal to the hange in the external pressure acting on the condensed phase, divided by he pressure which this phase as an ideal gas would exert. Proceeding in this way, the conclusion is drawn that the thermic pressure of a phase is equal to the pressure which it would exert under the same conditions, if it were to behave like an ideal gas, and the proposal is made to measure temperature in

the kinetic theory, not by mean kinetic energy but by mean momentum, *i.e.*, by the thermic pressure.

Finally the fundamental theorems of van't Hoff and Raoult are "deduced" from a general theorem concerning "transition-tendencies," and the author's "gas equation," $P = \frac{RT}{v} - \alpha$, where $\alpha = \alpha(v, T)$ is discussed. F. G. D.

419. *Irregularities of Cadmium Cells.* **W. Jaeger.** (Zeitschr. Instrumentenk. 20. pp. 317–324, Nov., 1900.)—The behaviour of the Weston cell is entirely different from that of the Clark cell, since there is no well-defined transition-temperature, and the e.m.f. of the abnormal cells does not lie along any regular curve. The experiments of the author refer to cells containing a 14·3 per cent. amalgam. Out of thirty-four cells tested at 0°, fourteen showed deviations amounting to less than 0·2 millivolt, and the errors in the remainder ranged quite continuously from + 0·2 to + 1·5 millivolts, one cell only showing a larger error of + 2·3 millivolts. Two of the cells which showed a deviation of + 0·8 and + 1·1 millivolts respectively at 0°, and one normal cell, were tested at temperatures ranging from — 16° to + 40°. The deviation of the normal cell from the e.m.f. calculated by the author's formula was greater than 0·3 millivolt in only one out of thirty-two observations, and that was at a temperature of — 11·5°. The two abnormal cells showed no deviation greater than + 0·3 millivolt when the temperature was between + 10° and + 40°, but varied irregularly below that temperature, the maximum deviation being + 4·49 millivolts at — 16°. It would therefore appear that a Weston cell containing a 14·3 per cent. amalgam which has been standardised at any one temperature can be relied upon at all temperatures between 10° and 30°, but is liable to error below 10°.

These errors are probably due to a change in the amalgam, similar to that which takes place in the concentrated amalgam at ordinary temperatures, and not to a change in the cadmium sulphate. The errors can be eliminated by using a less concentrated amalgam; a 13 per cent. amalgam is now used at the Reichsanstalt, and the cells of the European Weston Electrical Instrument Company, which contain a 12·5 per cent. amalgam, are probably free from error. T. M. L.

420. *Reaction Velocity in Electrolytic Reduction.* **H. Goldschmidt.** (Zeitschr. Elektrochem. 7. pp. 263–266; Discussion, pp. 266–269, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—When an alcoholic, alkaline solution of nitrobenzene is electrolysed, a portion of the liberated hydrogen escapes in the gaseous state at the kathode, whilst the remainder is used in the reduction of the nitrobenzene. If the current is gradually diminished a point is reached when no free hydrogen escapes, and the current is then proportional to the velocity of the reaction. Experiments of this kind made by Malzi and also by the author show that the concentration (C) of the reducible substance and the maximum current (J_m) are connected by the equation $J_m = C_{\frac{3}{2}} \times \text{Const.}$ In the method of working above indicated it is necessary to lead a current of hydrogen through the liquid to promote equality of concentration, and since this must be stopped in order to observe the point at which hydrogen ceases to be evolved at the kathode, errors are introduced into the observations. A better method consists in separating the electrodes by a porous cell and measuring the e.m.f. of polarisation for increasing currents. The values thus obtained are plotted out, when a sharp break in the curves indicates the points at which

he evolution of hydrogen ceases. Experiments made in this way with nitrobenzene, the three nitrotoluenes, azobenzene, and azoxybenzene, at 25°, 35°, and 45°, confirm the validity of the law stated above. This result is not in agreement with the researches of Haber, who, however, worked with very low current-densities. The temperature coefficient of electrolytic reduction is very small, a difference of 10° increasing the velocity constant by about a third only. On this point the author is in agreement with Haber and Tafel.

Discussion.—**Löb** suggested the use of a mercury kathode, the maximum current for which no amalgam is formed being taken as a measure of the reaction velocity. **Foerster** referred to the influence on the reduction of different kathode metals, and pointed out the extreme difficulty of ensuring that the general concentration of the electrolyte was identical with that actually obtaining at the kathode. **Nernst** stated that the measurements might have been made more simply and exactly by means of a third electrode; the reaction velocity, moreover, was closely connected with the diffusion velocity of the depolariser. **Bodenstein** said that the difference between the results obtained by Haber [Abstracts Nos. 1332 and 1333 (1900)] and Tafel [Abstract No. 2287 (1900)] was to be referred to diffusion velocities, the latter observer having used substances reducible with difficulty, and the former low current-densities, ample time being in either case afforded for diffusion. N. L.

421. *Electrolytic Separation of Iron and Nickel from Solutions of their Sulphates.* **F. W. Küster.** (Zeitschr. Elektrochem. 7. pp. 257–258; Discussion, pp. 258–259, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—The determination of the point at which iron and nickel are electrolytically deposited, either by direct observation or by examination of current curves, is unsatisfactory. The best results were obtained by maintaining a definite kathode potential for five to ten minutes by suitable variation of the e.m.f. of the bath, then immersing the platinum electrodes in hydrochloric acid and observing whether hydrogen was evolved or not. For all the concentrations employed nickel was deposited at a lower potential than iron, the average difference being about 0·1 volt. The influence of concentration is greater in the case of acid than in neutral solutions, whence it is inferred that compounds of the metals with hydrogen, or solid solutions of the metals in hydrogen, are primarily deposited.

Discussion: **Foerster** stated that previous experiments made by himself had yielded similar results. He also pointed out that, as a general rule, metals simultaneously deposited were obtained in a spongy condition, whereas bright, coherent deposits of mixtures or alloys of iron, nickel, and cobalt were as readily obtained as similar deposits of the pure metals. N. L.

422. *Arrangements for Electrolytic Analysis.* **H. Marshall.** (Soc. Chem. Ind., Journ. 19. pp. 992–994, Nov., 1900.)—This is a description of the electrolytic apparatus and equipment in use in the chemical laboratory at Edinburgh University. The resistances, ammeter, voltmeter, &c., are contained in a teak case with glazed front and lid, the working terminals for six experimental circuits being on the outside of the case. A number of diagrams are given in the paper. N. L.

423. *Electrolysis of Dilute Sulphuric Acid Containing Iron.* **K. Elbs.** Zeitschr. Elektrochem. 7. pp. 261–262; Discussion, pp. 262–263, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—The adverse influence of iron salts on the useful effect of the

current in the electrolysis of dilute sulphuric acid is well known, but no quantitative data seem to be available. Experiments with two gas voltameters in circuit, one filled with pure, dilute acid, and the other with acid containing known quantities of iron, show that 1 per cent. of iron, using a current density of 2·23 amperes per sq. dm., reduces the volume of gas evolved to 48·3 per cent. of the normal volume, whilst with a current density of 0·228 amperes the loss is 97·4 per cent. With 0·01 per cent. of iron, the loss is 1·7 per cent. for a current density of 2·217 amperes per sq. dm., and 6·3 per cent. for 0·36 ampere. These values were obtained by the use of platinum electrodes, but similar results were obtained with "formed" lead plates; hence it is concluded that the acid used for accumulators should not contain more than 0·01 per cent. of iron. A useful, practical test of the suitability of an acid is afforded by the fact that if no turbidity is produced within a few minutes after neutralisation with ammonia solution, the acid contains at most 0·008 per cent. of iron. N. L.

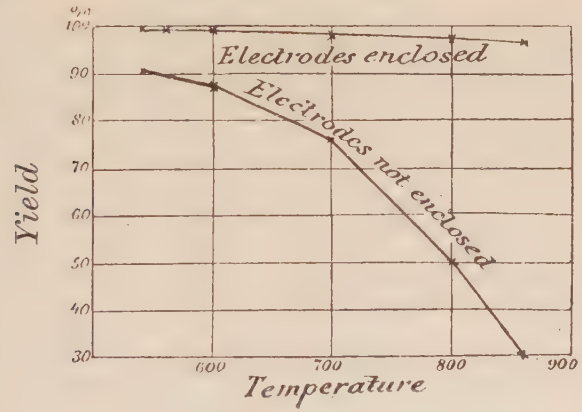
424. *Electrolysis of Copper Sulphate as a Basis for Acidimetry.* **C. A. Kohn.** (Soc. Chem. Ind., Journ. 19. pp. 962–963, Nov., 1900.)—A convenient quantity of pure copper sulphate is electrolysed in the usual manner, and from the weight of copper obtained the amount of sulphuric acid simultaneously formed is calculated. The solution can thus be used for checking the strength of standard alkaline and acid solutions. The copper sulphate employed must be free from other metals but need not itself be weighed, the accuracy of the process depending simply on the volumetric titrations and the theoretical ratio of copper to sulphuric acid. N. L.

425. *Experiments on the Electrolysis of Fused Salts.* **R. Lorenz.** (Zeitschr. Elektrochem. 7. pp. 277–286; Discussion, pp. 286–287, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—An account is here given of the work done by the author and his various assistants during the last four years in order to arrive at the chief laws underlying the electrolysis of fused metallic halogen compounds. The lecture was accompanied by a series of experiments. Subjects dealt with are current efficiency, determination of polarisation, e.m.f. generated, conductivity, conformity with Faraday's law, and also the action of the finely diffused metals in their respective molten haloid salts, temperatures up to 1,000 C. being considered.

Various forms of apparatus are given and illustrated. A V tube of glass, or porcelain (according to temperature), enclosed in an air bath consisting of an inverted truncated pyramid, with a movable lid, the latter admitting of easy regulation of temperature, is also described. A cylinder, vertically inclined, surrounded by two superimposed circular Fletcher furnaces, the lower one giving access to the flame from a blowpipe through a hole, while the upper one allows the flame to escape to an opening on the opposite side, may also form a suitable arrangement for the purpose of keeping molten salts at a uniform temperature. Two forms of electrically heated furnaces, consisting in the main of carbon cylinders heated by a suitable current, variable at will, and only differing in the manner in which the contacts are made, are explained.

The electrolysis of molten zinc chloride is first considered, and the fact mentioned that there are two kinds of this compound, viz., one which is easily electrolysed, and the other only with difficulty. In the case of the latter, on passing the current, hydrogen only is generated at the kathode, but no zinc,

ıd only a very little chlorine at the anode, and as both electrodes consist of ırbons, the anode is appreciably attacked. As the electrolysis proceeds, ıely diffused zinc is given off. A current may be passed for hours through ı electrolyte of this composition without giving any results. The "easily" ectrolysed zinc chloride, obtained by previous treatment of the "bad" ıriety with an excess of hydrochloric acid and subsequent evaporation and sion, yields pure chlorine and zinc from the very beginning of the ectrolysis. The cause is to be sought in the hydrolysis of $ZnCl_2$, viz., $nCl_2 + 2H_2O \rightleftarrows Zn(OH)_2 + 2HCl$. This observation also holds good for ıe chlorides, bromides, and iodides of a number of other metals forming ıygroscopic salts. The next phenomenon dealt with is the diffusion of metals hen introduced into their molten chlorides. Lead, for instance, on being ıised under a layer of lead chloride in a tube of hard glass, according to the mperature employed, gives off a "fume" of very finely divided lead above ıe surface of the molten metal, which is at first dissolved by the chloride. fter saturation, the latter is rendered turbid and non-transparent, the height



f this opaque layer varying directly with the rise of temperature. The fume" of zinc under such conditions is a beautiful blue, that of cadmium eddish brown, lead dark brown, and silver quite black.

This solution or diffusion of metals in their chlorides, has hitherto been xplained by the formation of sub-chlorides. The metal is always first volved and distributed in this manner before saturation is reached, giving se to recombination with the haloid evolved, which results in polarisation. his explains why on the passage of small currents, say ½ ampere, no visible lectrolysis takes place, and hitherto many of these bodies have, according to heir behaviour, been looked upon as metallic conductors (lead chloride). If, owever, the electrodes are surrounded by a tube preventing this diffusion of ıe ions given off, this recombination does not take place with varying mperatures, as will be seen from the curves in the accompanying diagram.

A further deduction drawn from this is, that when the yield is *nil*, there is o counter-e.m.f., and, on the other hand, that with the highest yield there the maximum of counter-e.m.f. This is proved by passing chlorine gas ver molten lead in lead chloride.

A discussion followed the paper. O: J. S

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

426. *Trials of Steam Engines with and without Jackets.* (Mech. Eng. 5 pp. 519–521, Oct. 18, 1900)—This is an account of a series of trials made by M. Longridge on a mill engine to test the efficiency of jackets. The engines are said by [illegible] compound jet-condensing fitted with Corliss valves. Cylinders are jacketed on the barrels and the ends and a steam coil is fitted in the receiver. Jackets, coil and receiver are drained by steam traps to the steam separator in the main steam pipes. The following are a few of the principal results arrived at :—

	[illegible]	[illegible]
Boiler pressure	147 lbs.	148 lbs.
Vacuum	27·1 inches	27·2 inches
Steam pressure in jackets, h.p.	—	147 lbs.
" " " l.p.	—	124 "
[illegible] receiver	[illegible]	[illegible]
Revolutions per minute	64·8	65·1
i.h.p.	524	521
Steam per i.h.p. to cylinders	14·55 lbs.	13·21 lbs.
" " jackets	—	0·68 "
Total steam per i.h.p.	14·55 lbs.	13·89 "
Heat consumption of engine in B. Th. U.	284	271
Thermodynamic efficiency of engines	0·568	0·596

[Illegible] cylinder, 14·11 inches diameter and the [illegible] 48 inches with 4 feet stroke. Steam was supplied by two water-tube boilers in which due to the conditions it was somewhat difficult to measure the difference of water level, but the error is probably less than 2 per cent.

Combined indicator diagrams plotted from the indicator cards are given.

L. S. R.

427. [illegible] A. Coats. (Elect. Engng. 26 pp. 477–478, Oct. [illegible] Oct. 19, 1900.) Paper read before the Liverpool Technical College Scientific Society.—Early attempts at [illegible] engines called for principles of construction [illegible] Owing [illegible] and [illegible] to [illegible] [illegible] [illegible]

...d to be increased, initial condensation is proportionately decreased. The ...tion of steam jacket, or buffer, is discussed at length, and if the buffer is ...ved from the influence of the oil bath steam is preferable.

...ley & McLellan; and the Marine Steam & Turbine Co.'s high-speed ...ines are fully described. The former engine is dealt with and the ...ount of the water condensed in the jackets when giving the steam ...mption of the engine is alluded to. Table of tests is also given. The ...er then describes an engine designed by himself. The engine is fitted ...h a steam buffer whose clearance can be altered. The effects of inertia at ...rious portions of the stroke are also discussed at length and the bearing ...e pressure in the buffer on these is dealt with. The results of some ...ensive tests give the consumption as slightly under the Williams engine ...h a mechanical efficiency of 82 per cent. L. S. R.

AUTOMOBILISM.[1]

...28. Traction Effort. M. G. Forestier. (Horseless Age, 7 pp. 18–19 ...1, 1901). Paper presented to the International Automobile Congress at ... The various resulting forces which constitute the coefficient of ...ion on common roads are placed under the following heads: (1) friction ...e journals in the hub bearings expressed by the formula $T_1 = \phi \frac{P}{D}$ ... P = dia. of spindle, D = exterior diameter of wheel, p = load on ...e hub, and ϕ a coefficient variable with the nature of the lubri...nt and the surfaces in contact. For a given type of vehicle, in order ...educe the axle friction, the ratio P/D may be reduced, and also the ...efficient ϕ. Formerly, with taper axle spindles and solid lubricant, the ...e of ϕ was about 200 lbs. per ton, but by the employment of a good ...id lubricant with a "demi-patent" collar the value of ϕ has been ...uced to about 20 lbs. per ton. With ball or roller bearings, ϕ varies from ...0 lbs. per ton. With plain bearings an excess of oil must be avoided as ...e passes of lubricant the coefficient of friction increases as the square of ...e speed.

...) Resistance to translation on the road. This if the translation is ...ly rolling is expressed by $T = (f \pm i)\frac{P}{D}$ where P = total weight of ...cle in tons, i = the inclination expressed in thousandths, and f a co...ficient variable with the road surface and the diameter D of the ...els. In practice T also comprises all the force necessary to overcome ... roughnesses of the road expressed by $P\sqrt{\frac{h}{D}}$, in which h = height of ...ticle; (c) the resistance due to depressions or holes in the road surface. ...t has been shown that for two-wheeled vehicles the pull on concave parts of ...e road is $\theta\sqrt{\frac{1}{1-\frac{R}{R_1}}}$ where θ = pull on the level, R = radius of wheel, ... = radius of curvature of undulations; and for convex parts of the road the ...ll is $\theta\sqrt{\frac{1}{1+\frac{R}{R_1}}}$; (c) the resistance due to deformation of the road

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[1] Electric Automobiles are dealt with in the section dealing with Electric Traction.

surface under the weight of the vehicle, which according to Cariolis is expressed by $Tn = \frac{3}{8}\sqrt[3]{\frac{12}{m\,p} \times \frac{P^4}{D^2}}$, in which m is a coefficient depending on the hardness of the road, and p = width of tyres; (d) the resistance due to describing curves, for which, in the absence of methodical experiments, no data can be given.

(3) Losses due to the vibration of the vehicle. The author does not investigate theoretically this source of loss of energy, but the following table, based on experiments with a Panhard and Levassor petrol car with solid rubber tyres, is given as showing the values of the 2nd and 3rd terms of the traction resistance coefficient per ton :—

	Tyres.	
	Rubber.	Steel.
Good macadam, fairly dry	30 lbs.	33 lbs.
Slightly defective macadam, fairly dry	36 „	40 „
Good macadam, wet	40 „	44 „
Slightly defective macadam, wet.....	44 „	49 „
Unsettled macadam	50 „	55 „

(4) Air resistance, expressed by $T_a = K.\,S.\,V^2$, where S is the surface in sq. metres of vehicle projected on a plane normal to direction of motion; K is a coefficient varying with the nature of the vehicle, assumed to be = 0·0288 for automobiles, and V is the velocity of the vehicle in metres per second. For an area of 1 square metre, and for 1 square yard the following figures are given :—

Speed in km. per hour...	6	8	10	12	15	20	25	30	36
Air pressure in kg.	0·079	0·142	0·221	0·317	0·498	0·887	1·387	1·998	2·88
In English measure—									
Miles per hour	3¾	5	6¼	7½	9	12½	15⅝	18	22½
Air pressure in lbs. per sq. yd.	0·145	0·261	0·406	0·580	0·917	1·62	2·55	3·67	5·22

(5) Acceleration, expressed by the term $\frac{P}{g}\frac{dv}{dt}$, which shows the advantage of slow starting and of maintaining uniformity of motion.

Tyres.—Under this head the author considers the question of broad and narrow tyres, and points to cases in which a decrease in breadth of tyre has been made with advantage. The advantages of tangential spoke wheels over wood wheels are also considered.

Suspension.—The following table, from experiments by Dupuit, is given as showing that spring suspension may increase the coefficient of traction :—

	Gravel road.	Paved road.
Cart without springs	60 lbs.	34 lbs.
Spring-suspended public conveyances ...	60 lbs.	40 lbs.
Private spring-suspended vehicles	72 lbs.	68–74 lbs.

The increase caused by suspension diminishes as the speed increases. In general, however, the reduction, by spring suspension, of loss of motive power due to shocks on rough roads is undoubted. C. R. D'E.

429. *Calculation of Motive Power for Automobiles.* **S. A. Montel.** (Écl. électr. 24. pp. 393–395, Sept. 8, 1900.)—In an automobile moving on the level, the forces opposing motion are of two kinds, some, such as bearing-friction and the friction of the wheels against the ground, being independent of the speed, and others, such as air-resistance and the resistance produced by shocks due to irregularities of the road being proportional to the square of the speed. Let v be the car's velocity at the moment t when f is the sum of the former forces, and av^2 the sum of the latter forces. Then the total force opposing motion is $f + av^2$. If the road is not level, we must also consider another force f' which is the component of the car's weight parallel to the ground. The total force F opposing motion is then—

$$F = f + av^2 \pm f' \qquad (1)$$

Considering only those cases where F is opposed to the car's motion (*i.e.*, if downhill, f' must be $< f + av^2$), if p is the total weight of the car and g is the acceleration due to gravity, then at every instant

$$\frac{p}{g} \cdot \frac{dv}{dt} + F = 0 \qquad (2)$$

where $\frac{dv}{dt}$ is the fall in speed in unit time due to the force F. To find F, we deduce from (1) and (2) that

$$-\frac{p}{g\sqrt{a(f \pm f')}} \cdot \frac{d\left(v\sqrt{\frac{a}{f \pm f'}}\right)}{1 + \frac{a}{f \pm f'}v^2} = dt,$$

whence by integration, and remembering that when $t = 0$, $v = V$, the speed of the car at the moment when power is cut off, and also that at a certain time t_0, $v = 0$, we get—

$$\tan^{-1} \frac{V}{\sqrt{\frac{f \pm f'}{a}}} = \frac{gt_0\sqrt{f \pm f'}}{p}\sqrt{a} \qquad (6)$$

Now t_0 and V can be readily observed: hence this equation gives us a relation between $f \pm f'$ and a, and if we can find the former, we can obtain a by successive approximations. For low or moderate speeds, av^2 is negligible compared to f or $f + f'$, but possibly not to $f - f'$. Assuming that av^2 is negligible, we can by integration find that

$$v = V' - \frac{g}{p}(f \pm f')t \qquad (8)$$

where V′ is the speed (not great) at time $t = 0$ when power is cut off. Remembering that after a time t', $v = 0$, we find from (8) that

$$f \pm f' = \frac{V'}{t'}\frac{p}{g} \qquad (9)$$

whence we can determine $f \pm f'$. In view of our assumptions, this determination will be more accurate the less the gradient of the road. If we make two trials in the uphill direction, in the first cutting off the power when the speed has a high value V, and in the second when the speed is low, V_1, and two similar trials in the downhill direction, then by equations (6) and (9) we can find f, f', and a. Having found these, the power W required by the car is given by $W = FV$. For the trials, the route should be straight, evenly graded and smooth. E. H. C.-H.

430. *Gillet-Forest Petrol Car.* **P. Sarrey.** (Locomotion Automobile, 7 pp. 690–693, Oct. 25, 1900.)—A single-cylinder, horizontal motor is placed in the front of a tubular underframe, which carries the driving mechanism and the body, and which is suspended by springs upon the front and rear axles. The motor develops 5 h.p. at 800 r.p.m., but its speed can be varied from 100 to 1,200 revolutions and its power from 2 to 7 h.p. The diameter of the piston is 120 mm., and its stroke is 140 mm. The crank-shaft, the cam-shaft, the centrifugal governor, and a pair of bevel wheels (which transmit the power from the motor) are all enclosed in an aluminium crank-chamber. The governor varies the position of a special exhaust cam upon the cam-shaft: this cam is so shaped that the extent to which, and the moments at which, it operates the exhaust valve depend upon its longitudinal position on the shaft. When it is desired to depart from the normal engine speed, the cam-operated lever is moved by hand longitudinally relatively to the cam, but the action of the governor upon the cam is not interfered with. Electric ignition is fitted and provision is also made for the use of a lamp-heated tube. The cylinder and the valves are water jacketed. The cooling water circulates without the aid of any pump through a radiator in front of the car; a constant-level device is used for regulating the flow of water, and it is said that 6 litres is sufficient for a run of 300 km. The power is transmitted to a differential gear, in the centre of the "live" rear axle, through a friction clutch and a change-speed gear, both of which are fixed to the underframe, and through a universally jointed shaft to a pair of bevel wheels inside the differential gear-case. The change-speed gear is of the toothed-wheel type and provides three speeds (9, 18, and 32 km. per hour) forward, and one speed (6 km.) backwards; of the forward speeds two are thrown in and out of use by sliding the driving gear-wheels in and out of mesh with the corresponding wheels on the driven shaft; the gear-wheels forming the third speed are always in mesh with one another, but that on the driving shaft is mounted freely and can be clutched to its shaft by sliding the second speed gear-wheel into engagement with it. Three band brakes are provided; two of these act upon the hubs of the rear wheels and the third is fitted upon the universally jointed transmission shaft. Wheel steering, in which a quadrant and a toothed-wheel connect the inclined steering pillar to the front wheels, is employed. All four wheels are made of wood, are fitted with pneumatic tyres, and are 80 cm. in diameter. A. G. N.

431. *Delahaye* 14-*H.P. Petrol Car.* (Locomotion Automobile, 7. pp. 722–724, Nov. 8, 1900.)—This vehicle differs considerably in design from the 7 and the 9½ h.p. carriages previously made by this firm. The motor, which is fixed horizontally at the back of the underframe, is not only larger than those hitherto employed, but its two cylinders are fitted with variable-timing electric ignition, and with small compression-relieving exhaust cams which are so arranged that they come into operation when starting the motor and when setting the ignition device to its latest position. A plan of the underframe is given in the article, and this shows the general arrangement of the mechanisms. The power is transmitted from the crank-shaft, at the back of the car, to the change-speed gear, in the centre of the frame, by means of a single belt which is normally held by a spring upon a loose pulley, but which can be moved by the driver on to a fast pulley. The change-speed gear is of the toothed-wheel type in which the wheels on the first motion shaft can be moved into mesh with those fixed upon the differential gear counter-shaft. Side chains transmit the power from this counter-shaft to each of the rear driving wheels. Three forward and one reverse gears are provided. A. G. N.

432. *Buchet 6-H.P. Petrol Motor.* **R. Delevoye.** (Locomotion Automobile, 7. pp. 724–725, Nov. 8, 1900.)—A description, with sectional drawing, of a single-cylinder, water-jacketed petrol motor in which the exhaust valve is placed centrally in the cylinder head. The admission valve also opens direct into the combustion chamber. The cylinder bore and stroke are both 100 mm. Owing to the absence of resistance to the entrance of the explosive mixture and to the exit of the exhaust gases, the power developed by the motor at high speeds is considerably increased. Three tests gave the following results: 6·72 b.h.p. at 1,600 r.p.m., 6·78 b.h.p. at 1,804 revs., and 7·2 b.h.p. at 1,872 revs. A comparison of the specific displacement of this motor with that of other well-known types is given as follows: De Dion $1\frac{3}{4}$ h.p., 66 mm. bore × 70 mm. stroke, 11·8 litres per poucelet, giving 118 kg.m.-second; De Dion $2\frac{1}{4}$ h.p., 70 × 70, 11·6 litres per poucelet, giving 130 kg.m.-second; Buchet 6 h.p., 100 × 100, 9·53 litres per poucelet, giving 510 kg.m.-second; Panhard 6 h.p., 9·2 litres per poucelet, giving 490 kg.m.-second; Pengeot 6 h.p., 10·3 litres per poucelet, giving 530 kg.m.-second. The last two are slower speed motors, having greater expansion. Buchet is building similar motors of 12 and 24 h.p.; the smaller size above described weighs under 100 kg. A. G. N.

433. *Remington Motor and Carburettor.* (Horseless Age, 7. pp. 12–13, Oct. 10, 1900.)—This article describes a gasolene motor in which four horizontal cylinders are arranged in pairs opposite to one another on either side of a common crank case. Each cylinder has two pistons, the movements of which are so arranged that at the completion of the exhaust stroke the pistons approach one another very closely, so that all the products of combustion are expelled. The firing of the charge in the cylinder is effected by means of an external flame and timing valve. The cylinders of an engine developing from 8 to 10 b.h.p. at 300 to 500 r.p.m. are $4\frac{1}{4}$-inch bore × $4\frac{1}{2}$-inch stroke, the weight of the complete engine being 300 lbs.

The carburettor is of a very simple form, in which air passes ever the surface of a wick which is kept saturated with petrol, the surface exposed to the air being variable. Illustrations of the engine and carburettor are given.

C. R. D'E.

434. *Cunningham Steam Truck.* (Horseless Age, 7. pp. 11–16, Oct. 3, 1900.)—This article describes and illustrates a form of heavy steam lorry now being manufactured by the Cunningham Engineering Co., of Boston, Mass. The general design consists of a platform with a cab in front containing the boiler and seats for driver and attendant, who have an unobstructed view ahead. The engines and driving gear are carried below the platform. All four wheels are drivers, steering being effected by a movement of the front axle upon a pivot and locking plate. Wood wheels with iron tyres are employed, equal diameter front and back. In the 3-ton lorry, 66 square feet of platform area, exclusive of cab, are provided; the wheel base is 9 ft. 6 in., and gauge 4 ft. 6 in.

The boiler is of the watertube type, with 120 square feet of heating, and 2 square feet of grate area; either coke or liquid fuel may be employed.

Each lorry has two compound engines, cylinders $3\frac{1}{2}$ inches and 5 inches diameter by 5 inches stroke, speed 300 r.p.m. The engines are designed for 200 lbs. steam pressure, and arrangements are made for admitting high pressure steam into the l.p. cylinders; they are placed on either side below the platform and have a common crank-shaft on which are two spur pinions,

each of which gears with two spur wheels, which drive through hydraulic clutches and pitch-chain gears to spur pinions on short spindles above either axle. These pinions engage with spur-wheel rings on the exterior of each differential gear, the power being thence transmitted through divided axles to the road wheels. A gimbal joint between the toothed ring and the case of the front axle differential permits the turning of the axle for steering purposes. Details are given of the hydraulic clutches and the brake gear acting on the exterior of these, but no practical results of performances of these vehicles are stated. C. R. D'E.

435. *Turgan Steam Omnibus.* (Locomotion Automobile, 7. pp. 738–740, Nov. 15, 1900.)—A brief description, with drawings of the steam generator and rough drawings indicating the general arrangement of parts. The vehicle is intended for carrying twenty passengers any distance. The driving mechanism is placed in front and consists of an upright tubular boiler and a pair of 20-h.p. compound engines. The boiler weighs 680 kg. and measures 1·20 m. × 0·80 m. × 1·20 m. high; it will generate 435 kg. of steam (at 15 kg. pressure) per hour, or 580 kg. with forced draught, and consumes 1 kg. of coal per 6 kg. of steam. The engines weigh 8 kg. per h.p., and are fitted with cylinders of 90 mm. and 170 mm. diameter by 130 mm. stroke; their normal speed is 600 r.p.m., and they are each coupled by a single chain to one of the rear wheels of the vehicle. Provision is made for admitting high-pressure steam into the low-pressure cylinders when necessary. Two independent feed pumps supply water to the boiler. A condenser is placed on the roof, and it normally prevents loss of water when travelling. The weight of the vehicle is 3,250 kg., and its maximum speed is about 22 km. per hour. The conclusions drawn from tests made with it are that an omnibus, weighing about 5 tons loaded, can commercially carry sixteen to twenty passengers over rough and hilly roads at an average speed of 15 km. per hour, and with a fuel consumption of 3 kg. of coal per km. A. G. N.

REFERENCES.

436. *Balancing of Engines.* **J. Macfarlane Gray.** (Mech. Eng. 6. pp. 168–171, Aug. 4; and 198–200, Aug. 11, 1900. Paper read before the Institution of Marine Engineers, May 14, 1900.)—An investigation dealing generally with the elements of the subject. H. R. C.

437. *French Trials of Alcohol for Automobiles.* (Automotor Journal, 5. pp. 72–73, Nov., 1900.)

GENERAL ELECTRICAL ENGINEERING.

438. *Transportable Electricity.* **W. A. T. Müller.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 149–150, April 15; and 164–166, May 1, 1900.)—A zinc lead-peroxide battery invented by Burgwall and Ofenschüssl is described in which the electrolyte is contained in a concentrated form in the pores of the peroxide plate so that when placed in water an electrolyte of the normal density is obtained. The peroxide plates are of the grid type, and are pasted with litharge mixed with alum which has been treated with a solution of caustic potash so as to form a plastic mass. Very hard and porous plates are so obtained which are also suitable for the manufacture of accumulators. The dried plates are immersed in concentrated sulphuric acid. To prevent absorption of moisture from the atmosphere the prepared plates are coated with potassium silicate. They may then be kept for a year without change. The negatives are zinc plates from 1·5 to 3·0 mm. thick, according to their size. The cell is charged by the addition of water. Curves are given showing that the e.m.f. on discharge remains for a long period about 2·3 volts. Each kilogram of the complete battery will give 30 watt hours. The zinc used is 60 grm. per hecto-watt hour. Plans are given of the arrangement of an automobile battery with celluloid boxes. The battery consists of 12 cells, and is designed to give 45 amperes at 27 volts. The working cost is stated to be from 1·2 to 1·5 marks per kilowatt hour.

W. W. H. G.

439. *Prediction of Capacity of Accumulators.* **C. A. Rossander** and **E. L. Forsberg.** (Elektrotechn. Zeitschr. 21. pp. 881–883, Oct. 25, 1900.)—This is a mathematical calculation for determining the requisite capacity of a battery that is discharged at various rates. It is based on the formula—

$$T \cdot J^{1\cdot4} = \text{constant}$$

where T is time of discharge and J the current during discharge. The value of—

$$\frac{it}{c} = \varepsilon$$

where i is the current, t the time of discharge, and c the capacity for this particular rate of discharge, which may be called the *discharge factor*, is calculated from the formula—

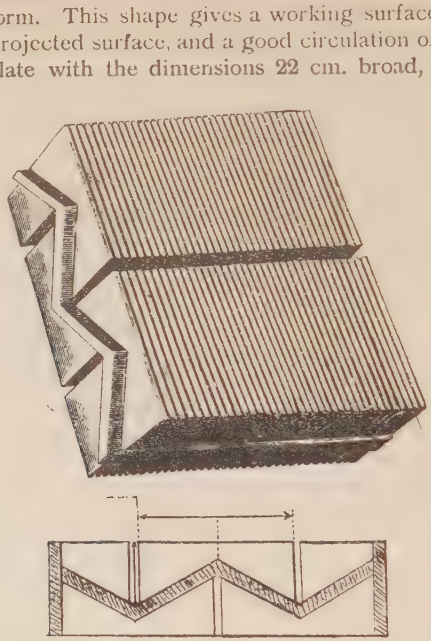
$$\varepsilon = \frac{(a + bT)^{2+v} - a^{2+v}}{Kb\,(2 + v)}$$

where the current increase is supposed to follow a linear law $a + bT$, $v = 0{\cdot}4$, and K is a constant. With the help of this formula the various discharge factors can be estimated and their sum will give the whole discharge. A graphical method is also described.

W. W. H. G.

440. *Omega Accumulator Plate.* **P. Weber.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 343–344, Oct. 15, 1900.)—A type of battery plate denoted "Omega," invented by Geoffroy and Delore, of Clichy, near

Paris, and manufactured in Germany by the Berliner Accumulatoren und Elektricitäts Gesellschaft, is described. The plate (see Fig.) has deep grooves and is provided with channels, so that from the end view it appears zigzag or wave form. This shape gives a working surface seventeen times greater than the projected surface, and a good circulation of the electrolyte is maintained. A plate with the dimensions 22 cm. broad, 27 cm. high, and



1·4 cm. thick, weighs 5 kg. Tests made in the Paris Laboratoire Central d'Electricité with such a positive plate between two negatives gave a capacity of 30–32·9 ampere-hours. Further measurements with a discharge of 100 amperes gave a capacity of 25 ampere-hours, the final voltage in each case being 1·7 volts. The capacity for a three hours' discharge was 54 ampere-hours. W. W. H. G.

441. *Porcelain Manufacture.* **J. Herzog** and **C. Feldmann.** (Elektrotechn. Zeitschr. 21. pp. 905–912, Nov. 1, 1900.)—The manufacture of porcelain is considered in particular relation to articles used for electrical purposes. Some details of the materials and their geographical distribution are given, together with notes on the extent of contraction which porcelain articles undergo in the process of firing. The contraction and loss of weight has to be anticipated in the moulding, and may amount to from 15 to 18 per cent. It has generally different contraction coefficients in length, breadth, and height, respectively. The glazing substance has to be selected of similar contraction-coefficient to the porcelain upon which it is to be placed. Errors in this selection result in one or other of two kinds of defects in the glazing, which are developed in subsequent changes of temperature. In both cases the glazed surface is broken, but the edges of the sutures may be either forced up by pressure against one another, or they may be separated. Moisture intrudes through these sutures in either case, and such porcelain is unsatisfactory for insulators. As an example of the methods adopted in forming various shapes and of firing porcelain articles, the manufacture of a land-line insulator is dealt with in detail. R. A.

442. *Eddy Current Loss in Iron Tubes and Armouring.* **C. Feldmann** and **J. Herzog.** (Elektrotechn. Zeitschr. 21. pp. 861-863, Oct. 18, 1900.)—When an iron tube surrounds a conductor through which alternating currents are passed, eddy currents are induced whose magnitude and effect are calculated. The eddy current loss W_f is given as—

$$W_f = \frac{M\sigma J^2}{1000ad^2} f l \, 10^{-7} \text{ watts},$$

where—

σ = specific resistance of the iron in c.g.s. units.
J = effective current in amperes in conductor.
a = half the thickness of the wall of the tube in cm.
d = mean diameter of the tube in cm.
l = its length in cm.
f = its cross section in sq. cm.

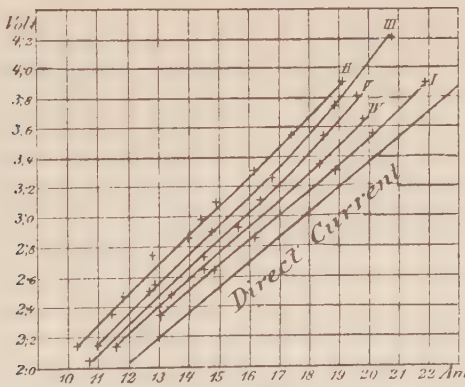
whilst—

$$M = 2\pi\sqrt{\frac{\mu \sim}{\sigma}}$$

μ being the permeability for average induction and $\sim$ the frequency.

A graphical construction is given to find the connection between the currents and the e.m.f.s involved, and practical cases are considered.

The article concludes with the description of an experimental investigation



made in the laboratory of the Helios Company to find the apparent resistance of 50 $\sim$ of a German silver wire of 0·168 ohms. The wire, 2 metres long, and glass beads strung on it, was placed in various iron tubes. The following results were obtained :—

No. of Tube.	Diameter of Tubes in mm. Outer.	Inner.	$4a$ in mm.	Apparent Resistance in ohms.
I.....	13·5	9·5	4	0·205
II.....	16·0	11·0	5	0·200
III.....	26·0	19·5	7	0·190
IV.....	33·0	25·0	8	0·186
V.....	59·6	51·3	8·3	0·180

The results with different currents and pressures are shown in the accompanying diagram.

W. W. H. G.

443. *Electric Elevator Control.* **H. Cochrane.** (Amer. Electn. 12. pp. 522–525, Nov., 1900. Abstract of a paper read before the Chicago Electrical Association.) —In the system here described, the motor is compound wound with the series coil divided into sections, and the controller is arranged first to short-circuit, step by step, a resistance in series with the armature; and then to short-circuit, step by step, the sections of the series coil on the motor field magnet. In order to prevent racing, the following automatic arrangement is employed, viz.: A stationary solenoid, in series with the shunt field coils of the motor, is arranged to act on an electromagnet which is in the armature circuit and is mounted on a longitudinally movable bar controlled by a spring. This bar bears contact pieces arranged on an insulating support and adapted to engage successively with a series of fixed brushes connected to the sections of the series field coils of the motor. When the motor commences to be driven as a dynamo by the load, the current reverses in the movable electromagnet and causes it to move against its spring so as to cut out, one by one, the series coils on the motor field magnet. If the current generated by the motor still increases, the sliding switch cuts the series winding into circuit again, but in the reverse direction, so that it strengthens the field of the motor and reduces its speed. An electromagnetic device is also described for actuating the controller from a switch in the elevator car, and also an elevator mechanism similar to Fraser's [see Abstract No. 1078 (1899)]. Diagrams of the connections and elevator mechanism are given in the original paper. C. K. F.

444. *Electric Crane at the Vienna Railway Station.* **E. Egger.** (Zeitschr. Elektrotechn., Wien, 18. pp. 526–532, Oct. 28, and 540–544, Nov. 4, 1900.)—This is a large hoist for lifting carriages a distance of 6 metres from the City Railway level to the level of the main railway. The cage or car is large enough to take a carriage 14 metres long and 3·2 metres wide, and weighing 30,000 kg., and the mechanism is such that this load can be lifted 6 metres in 1¾ minutes. It was at first intended that the hoist should be worked hydraulically, but on account of the expense and the fact that electric power was available from the public supply, besides the possibility that if worked hydraulically the pipes might freeze, it was decided eventually to use electricity.

Continuous-current motors are employed, working the gearing through double worms to avoid the end thrust. The cage is slung by heavy link chains, the motors and gearing, &c., being in a chamber immediately over the cage race. Full details are given of the construction of cage, and the gearing, switch gear, &c. The paper is illustrated by twelve figures, eight of them being line drawings. E. K. S.

REFERENCE.

445. *High-pressure Switches and Fuses.* **W. E. Warrilow.** (Elect. Engin. 26. pp. 189–190, Aug. 10; 224–229, Aug. 17; 274–276, Aug. 24; 307–310, Aug. 31; 371–374, Sept. 14; 417–419, Sept. 21; 488–492, Oct. 5; and 510–511, Oct. 12, 1900.) —A series of articles illustrated by drawings, describing the switches and fuses of several well-known makers.

GENERATORS, MOTORS, AND TRANSFORMERS.

446. *Magnetic Attraction in Dynamo Design.* **B. A. Behrend.** (Amer. st. Elect. Engin., Trans. 17. pp. 599–608, Nov., 1900.)—In large motors or nerators with small clearance, tremendous mechanical effects are caused by magnetic forces, and it is of the greatest importance when designing them be able to calculate the forces called into play when the axes of the arma- e and field are not in exact coincidence. The ordinary formulæ which are tained on the supposition of two parallel magnetic planes facing one other are given and discussed, and it is shown that they are of little practical e. The author considers the problem of the magnetic forces between two linders one inside the other with their axes parallel but not quite coincident. e deduces the following formula for the resultant force, which he says is a ost useful and important one :—

$$F = \frac{1}{4\pi} S B^2 \frac{d_2 - d_1}{d_2 + d_1}$$

is the resultant force in dynes, S the curved surface of the inner cylinder square centimetres, B the induction, d_2 the greatest and d_1 the least value the air-gap.

Experiments made on a 300-h.p. inductor generator for 2,000 volts are scribed, and the experimental figures are compared with the figures given the above formula. The bearings of the generator were opened and the ld was excited while the inductor was standing still. At 18 amperes' excita- n the inductor, with shaft weighing 8,400 kgs., was lifted up from the arings until it clung to the armature frame. When the excitation was wered to 8 amperes the inductor and shaft fell back into the bearings. ow at 18 amperes' excitation and a frequency of 50, the generator gave 1,400 lts on open circuit, and at 8 amperes it gave 640 volts. From which it llows that B = 5,900 at 18 amperes and 2,700 at 8 amperes. But in the ex- riment the magnetism at 8 amperes was attained by lowering the excitation, d as in inductor machines the descending curve of magnetisation often lies per cent. above the ascending curve, the author assumes that when the rrent was 8 amperes B was 3,100. Now S = 9,350 cm.², d_2 = 0·46 cm., = 0·26 cm. Substituting in the formula we get F = 7,400 kg. when B is 00 c.g.s. In the second experiment d_2 = 0·72, d_1 = 0, B = 3,100, hence is 7,340 kg. The observed value was of course 8,400 kg. Considering the any sources of error, the agreement is fairly satisfactory. A. R.

447. *Calculation of Air-gap Ampere-turns for Toothed-core Armatures.* **W. ander.** (Zeitschr. Elektrotechn., Wien, 18. pp. 562–564, Nov. 18, 1900.)— ne author's method is based on the assumption that the tops of the teeth and e sides and bottoms of the slots constitute an equipotential surface. He aws a diagram showing the approximate shape of the lines which pass from e polar surface into the top and flanks of a tooth and the bottom of a slot. he induction at any point on the surface of the core is taken to be inversely oportional to the length of the line passing through that point. From the agram of lines the average length of a line for the top of a tooth, its flank, id the bottom of the slot respectively, may be ascertained graphically.

Further, since the areas of the tops of the teeth under cover of the pole-piec and of the flanks of the teeth and bottoms of the slots are known, the ratios o the total fluxes entering the tops of the teeth, their flanks, and the bottoms o the slots are known. But the sum of these three fluxes is known, since represents the total magnetic flux entering the armature. Hence the averag induction along any one of the three paths may be determined, and whe multiplied by the length of path gives the required difference of magneti potential. A. H

448. *Iron Losses in Generators.* **G. Dettmar.** (Elektrotechn. Zeitschr 21, pp. 944–948, Nov. 15, 1900.)—The actual iron losses occurring in a generator are known to exceed, in most cases, by 150 to 200 per cent., bu sometimes by as much as 350 per cent., the calculated losses. This large divergence has hitherto been regarded as mainly due to eddy currents pro-duced by the tooling of the core-discs after they have been assembled. The author points out that the true explanation of the effect is to be looked for in the losses taking place in the pole-pieces ; he further criticises the commonly adopted method of calculating the core losses, which is based on taking for the maximum value of the induction the quotient of the flux by the cross-section of the core. Such a value of the induction is only correct for the inner portions of the core ; the outer portion, lying immediately below the teeth, is as a rule subject to a much higher value of the induction, and this fact should be taken into account. The author divides the core into a series of concentric rings, and by drawing a diagram giving approximately the distribution of the lines, determines the mean value of the maximum induction in each ring. The hysteresis loss is then calculated for each ring, and the results added together. By comparing the results obtained by the use of this method with those of the ordinary method, the author finds that the former exceed the latter by some 50 per cent. Dealing with the loss in the pole-pieces, he describes some experiments in which the distribution of the lines over the pole-face was studied by means of iron-filings pictures, the filings arranging themselves in a series of parallel strips corresponding to the regions of the pole-face opposite the teeth of the core. The pictures so obtained are applied by he author to determine approximately the depth of the layer in the pole-piece throughout which the induction is not uniformly distributed. The author points out the importance of eddy-currents in producing a screening action, but makes no attempt to establish a formula for the total loss occurring in the pole-pieces. A. H.

449. *A Belgian Steam Alternator.* (Écl. Électr. 25. pp. 249–258, Nov. 17, 1900.)—This set was exhibited at the Paris Exhibition by Van der Kerchove, who supplied the engine, and the Compagnie Internationale of Liège, the makers of the alternator. The engine is horizontal tandem compound, with cylinders 63 cm. and 109 cm. diameter, stroke 120 cm., speed 100 r.p.m. The normal i.h.p. is 1,000, with a pressure of 9 kg. per sq. cm. and cut-off at 0·2 ; the h.p. rising to 1,800 when the cut-off is at 0·6. There is a vertical piston valve at each end of each cylinder, these valves being so designed that they act as steam separators, while the exhaust permits the escape of any water condensed in the cylinder. Also the clearance space is very small, the friction and wear are low, and the valves are equilibrated at all pressures. The dashpot, which comes into action after the closing of the port, is of the simplest construction, and suffices for all conditions without readjustment.

governor acts either on both cylinders or on the high-pressure cylinder

The magnet flywheel of the alternator weighs 39 tons, and is made in pieces. Its diameter overall is 5·5 metres. There are 72 poles, each und with 105 turns in five layers; the windings are connected in two sets in allel, each of 36 in series, the resistance being 0·5 ohm. The carcase the external armature is cast in four parts which are bolted together. ch casting forms half of one side, and the armature sheets are fixed by s between the two sides. The air-gap measures 8·5 mm. There are slots per pole. Each armature coil has five turns of 32 sq. mm. section, is tested with a pressure 3,000 volts above the working pressure. All the s of each phase are in series, and the three circuits are star-connected. resistance of each circuit is 0·125 ohm. The total weight of the armature 0,500 kg. The exciter armature is on the main shaft, and the eight-pole gnets are compactly mounted on the stator. Its power is 23 kw. at volts.

The exciting current for 2,200 volts on open circuit is 110 amperes. On rt circuit the full load of 262 amperes is obtained with an excitation 75 amperes. With a power-factor of 0·85, the excitation at full load is mated to be 160 amperes, and the pressure drop 11 per cent. W. H. E.

450. *Steam Alternator by Sulzer and Brown-Boveri.* (Écl. Électr. 25. pp. 0–306, Nov. 24, 1900.)—This 1,760 kw. set was shown at the Paris Exhibition. e engine has triple expansion, with four cylinders, two being low pressure. e diameters of the cylinders are 60, 85, and 102·5 cm.; stroke, 150 cm.; ed, 80 r.p.m.; steam pressure, 11 kg. per sq. cm. [154 lbs. per sq. in.]. e normal power is 1,700 h.p., with cut-off at 0·3, and 1,950 with cut-off ·4. Each of the two low-pressure cylinders is in tandem with one of the ers. The governor controls the position of the eccentrics actuating the ission valves of the high-pressure cylinder. The admission of the other e cylinders is regulated by hand, as well as the four exhausts.

The alternator is a three-phase machine giving 170 amperes per phase at 0 volts, or 6,000 volts between terminals. Its internal rotating magnet 72 poles, and measures 6·9 metres in diameter overall. Each pole has turns, and the resistance of the 76 coils in series is 0·33 ohm. The nature carcase is supported by two sets of radial arms, giving great dity with moderate weight, and admitting of rotation of the armature inspection or repair. It is made in two halves, which hold the core plates ween them by bolts passing through the plates. There are six holes per e and 36 coils per phase, with twelve turns per coil. The air-gap measures m. Excitation is supplied by a 25 kw. four-pole dynamo giving 110 volts, driven by a separate vertical engine running at 300 r.p.m. The exciting rent, on open circuit, is 176 amperes for 6,000 volts; on short circuit amperes of excitation give 170 amperes per phase. On full load of 0 kw. with a power-factor of 1 the exciting current is 193 amperes; with ower-factor of 0·85 for an effective load of 1,500 kw. the current required 31 amperes, and at no load the rise in pressure is 11·5 per cent.

Another alternator by Brown-Boveri is driven by an engine made by mley, of Moscow. This 250 kw. alternator has an external rotary field usually employed by Brown-Boveri when the power of the machine is not great and when the engine is suitable. With this arrangement the magnetic effect between magnet and armature is opposed by centrifugal force. e internal diameter of the field is 3·60 cm., and the polar width 30 cm. e gap measures 5 mm. W. H. E.

451. *Theory of Synchronous Motors.* **Colard.** (Assoc. Ing. Él. Liège Bull. 11. pp. 346–384, Sept. 30, 1900.)—If V = terminal p.d., assumed constant; ρ = impedance of motor armature (also assumed constant); tan γ = resistance/reactance; p = torque-producing power; e = e.m.f. of motor and I = current; then, putting—

$$\frac{e}{V} = \sqrt{x},\ \frac{I\rho}{V} = \sqrt{y};\ \frac{2p\rho}{V^2} = z,$$

the author establishes the equation—

$$1 - x - y = z \,.\, \sin\gamma \pm \cos\gamma\,\sqrt{4xy - z^2}.$$

This equation represents an elliptic paraboloid whose sections by a series of planes parallel to the x-y plane give the power ellipses. The extreme values of x or y corresponding to a given value of z are given by—

$$\frac{1 - z\sin\gamma \pm \sqrt{1 - 2z\sin\gamma}}{2\sin^2\gamma}.$$

The maximum power corresponds to $x = y = \frac{1}{4\sin^2\gamma}$; $z = \frac{1}{2\sin\gamma}$. The points on the ellipses of power for which y is a maximum or a minimum lie on the parabola—

$$x = 1 + y - 2\sin\gamma \,.\, \sqrt{y},$$

and those for which x is a maximum or a minimum on the parabola—

$$y = 1 + x - 2\sin\gamma \,.\, \sqrt{x}.$$

The method used by the author, in which the x-coordinate is proportional to the square of the motor e.m.f., the y-coordinate to the square of the current, and the z-coordinate to the power, enables us to study graphically the behaviour of a synchronous motor without the necessity of using quartic curves such as those employed by Steinmetz. A. H.

452. *Core Loss in Three-phase Transformers with Unsymmetrical Magnetic Circuits.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 21. pp. 991–992, Nov. 29, 1900.)—On account of the difference in the magnetic reluctances of the paths in a three-phase transformer whose core is asymmetrical, the open-circuit losses for the three phases are not identical. Imagine three straight laminated cores, I, II, and III, laid parallel to each other and united top and bottom by common yokes. At first sight, one would expect the core-loss in II to be less than that in I or III, and these two latter to be equal to one another. Wattmeter measurements show that the loss in II is really less than that in either I or III, but that the last two are *unequal.* In explaining this effect by means of vector diagrams, the author first considers an ideal transformer with no hysteresis loss, and finds that the current in II is exactly in quadrature with the p.d. (copper loss negligible), the current in I lags by say $90° + \alpha$, and that in III by $90° - \alpha$, behind the p.d. in each case. Hence, although the *algebraical* sum of the three wattmeter readings is zero, yet the readings do not vanish separately. The circuit I acts as a source, receiving energy from III, which acts as a sink. By reversing any two of the connections, this action is reversed. When there is a hysteresis loss, this is simply superposed on the results obtained with the ideal transformer, and thus the actual behaviour of the transformer is explained. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

453. *Calculation of Distributing Networks.* **Buffa.** (Assoc. Ing. Él. ège, Bull. 11. pp. 384–399, Sept. 30, 1900.)—The author develops a method calculating the distribution of currents in a given network which presents advantage over the method of Herzog and Stark that by means of a plementary equation it becomes possible to ascertain, at any stage in the ocess of solving the linear equations, whether an error has been committed, d if so, to trace the error. A. H.

454. *Copper Saving in Power Transmission.* **F. Spielmann.** (Elektrotechn. itschr. 21. p. 1007, Nov. 29, 1900.)—Referring to Bedell's paper on this bject [see Abstract No. 2499 (1900)], the author states that he regards the ultaneous transmission of a continuous and an alternating current along e same line, and their subsequent separate utilisation in independent circuits nnected to the far end of the line, as impossible. He further criticises some itorial comments on Bedell's paper. A. H.

455. *Effect of Wave Form on Capacity Current.* **F. G. Baum.** (Elect. orld and Engineer, 36. pp. 610–611, Oct. 20, 1900.)—When the applied e.m.f. ve is a sine curve the effective capacity current (C) is given by the uation—

$$C = 2\pi VKf,$$

here V, K and f are the volts, farads and frequency respectively. This rmula is not true for waves of other shapes. For example for a triangular ve the formula is—

$$C = 4\sqrt{3}VKf,$$

owing that the current is 10 per cent. greater than that given by the sine curve rmula. If, however, the half-wave be everywhere concave to the axis, *i.e.*, it have only one *maximum* value (E), then it is safe to use the sine curve rmula in practice. If C′ be the average current passing in and out of the ndenser then a little consideration will show that $C' = 4EKf$. Since $= \frac{\pi}{2\sqrt{2}} C'$ for a sine wave, we easily deduce the ordinary formula. The thor concludes by pointing out the importance of not having "jagged" aves on long power transmission lines as these waves may increase the pacity current 200 or 300 per cent. A. R.

456. *Periodicity of Alternating Currents.* **J. M. Andrews.** (Journal of lectricity, S. F. 10. pp. 57–59, Sept., 190 . Abstract of a paper read before e Ohio Electric Light Association, Toledo, Aug. 15, 1900.)—A comparison is ade of the advantages and disadvantages of the various frequencies in use. or ordinary purposes sixty cycles and forty cycles are recommended, the rmer where lighting is the chief load and the latter where motors pre- ominate. With frequencies above forty, difficulty may arise in the parallel

running of slow-speed, direct-coupled units having reciprocating engines, unless with the closest control through the revolution, and with favourable governing mechanism. The twenty-five-cycle rotary converter has the advantage of requiring little care in synchronising, and, being decidedly stable in running, can be wound with a series field to maintain the voltage constant, or even to increase it with the load. W. H. E.

457. *Condensers in Alternating Current Work.* **M. Leblanc.** (Écl. Électr. 25. pp. 264–268, Nov. 17, 1900. Paper read before the International Electrical Congress, at Paris.)—The author attempted as early as 1890 to split, by means of condensers, a simple alternating current into two currents in different phases capable of working a polyphase motor. Lately he has attempted, on somewhat similar lines, to make an alternating current motor which would have a power factor of unity. The want of good commercial condensers has hitherto prevented these machines being put on the market. He considers that Boucherot and Lombardi have shown how such condensers should be made. Great difficulties have been experienced from resonance effects with armoured cables. A machine in a Paris Central Station gave 4,000 volts safely when working on a resistance. When, however, it was connected to a concentric cable, the voltage being only 1,500, a torrent of sparks crossed the air-gap of the machine and set the insulating materials of the armature conductors on fire. This effect was due to resonance, and several other similar accidents are mentioned. He describes a case in which rotary converters introduced harmonics of about twelve times the normal frequency into the e.m.f. of the circuit owing to their commutators being divided into twelve segments. These harmonics cannot be detected by ordinary voltmeters ; electrostatic instruments, for example, are quickly put out of action, as they serve merely as spark-gaps. Again, the self-inductance of hot wire instruments is very appreciable at high frequencies. A theoretical research is given of methods of suppressing danger from resonance due to harmonics in the e.m.f. wave. In conclusion, the author states that an alternating current network should have either a very small or a very large capacity. In the immediate future networks will be constructed which will be resonant for the frequency of the ordinary working current. This will necessitate the use of alternators compounded for constant voltage, so as to avoid a dangerous rise of pressure, and in addition the capacity of the network must be increased as the load increases. It will be therefore necessary to use a condenser with each motor, transformer, or converter. A. R.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

458. *Crewe Electricity Works.* (Electrician, 46. pp. 233–235, Dec. 7, 1900.)—This station is worked on the direct current system, with three-wire distribution. Plant of about 500 kw. capacity is installed, and full details of the engineering design are given in the article. It may be mentioned that both feeders and distributors are lead-covered single conductors, which are laid solid in wooden troughing. The network is fed at two points, by two single feeders, no feeder running to the third wire ; these conductors have each a sectional area of 0·2 square inch. Five distributors are laid together in one trough ; of these, two 0·2 square inch conductors are for private lighting, two 0·1 square inch for the public incandescent lighting, and one 0·2 square inch conductor acts as a middle wire common to both. All the distributors are brought back to the generating station. W. H. S.

459. *Sydney Tramways.* **A. C. F. Webb.** (Elect. Rev. 47. pp. 745–747, Nov. 9; and 790–792, Nov. 16, 1900.)—The line runs along George Street, the principal thoroughfare in Sydney; the power-house, however, is arranged so that plant may be installed to run the whole system of present steam trams electrically. The system is overhead trolley and direct current, with buffer batteries.

The *boiler-room* contains 14 multitubular boilers, 16 feet long by 7 feet in diameter, having 72 tubes 4 inches in diameter. The feed water is heated by Davis hot-air economisers. The *engine-room* contains four 850-kw. sets, consisting of Allis compound horizontal engines coupled directly to General Electric multipolar generators. The engines have cylinders 26 and 48 inches by 48 inch stroke, and run at 100 r.p.m. The generators have twelve poles, the armatures being drum-wound in slots. They are provided with flywheels 20 feet in diameter, weighing 40 tons. The engines exhaust into Wheeler condensers. The batteries of accumulators consist of E.P.S. cells, 300 of type 23 and 300 of K 9 type. The overhead line has centre-pole construction, Mannesmann steel poles being used, with iron brackets; the trolley wire is figure 8 section of 0·13 square inch area, and suspended by Hillings and Spencer hangers.

The permanent way, which is double track, laid with 7-feet centres, consists of 83-lb. grooved rails laid upon concrete with a wood-block road bed; the joints are bonded with Edison-Brown plastic bonds. The feeder cables are Callender's make, 0·45 square inch section, and are laid underground in Callender-Webber casing. Return cables of the same section are laid between each track and connected to alternate rails on each side; the two cables are cross connected every 60 yards. These cables are coated with Stockholm tar.

The type of car chiefly employed is a combination bogie, carried on two four-wheeled bogies; the car is 36 feet long by 6 ft. 3 in. broad, and weighs 20 tons with equipment; its capacity is 48 passengers. The trucks are Brill and Peckham types.

Another line, the Rose-Bay line, is an extension of the Ocean Street cable line. It is only 1¼ miles in length, but 55 per cent. of the distance is composed of curves, and the gradients go up to 1 in 11. Two 150-kw. General Electric six-pole generators, running at 400 r.p.m., are driven by the cable engines at the Rushcutter Bay power-house by counter-shafting and belting. A battery has been erected of 240 R 9 type Chloride cells. Poles with side brackets are used for the overhead construction; these carry two overhead lines, one for down and the other for up cars. The feeder cables are of Callender's lock-coil type, laid direct under the footpath. The track is a single one, with three turn-outs; it is laid with 83-lb. rails, bonded with plastic bonds.

In North Sydney, over seven miles of line are now opened for traffic. Power is supplied from a main power-house at Ultimo by means of submarine feeders laid under the harbour. There are three battery stations—one at Ridge Street of R 9 Chloride cells, one at Spit Road of 215 K 19 E.P.S. cells and 20 R 9 Chloride cells, and one at Willoughby of 238 Chloride cells. A Tudor battery is under order for Ridge Street. At both the Spit Road and Willoughby feeder stations Parker boosters are installed, consisting of a motor, running at 950 r.p.m., driving a series wound generator giving 100 amperes at 500 volts. For the overhead line side pole construction is used for single track and span wires for double track lines.

The Middle Harbour line is laid with 90-lb. rails and 35-lb. guard rails on

ironbark sleepers, laid on ballast. The Mosman's Bay and Willoughby lines are laid with 60-lb. Vignoles rails, bonded with plastic and with Chicago-type bonds. The Gore-Hell line has 83-lb. rails and plastic bonds.

The articles contain load curves and numerous illustrations. G. H. B.

460. *Hydro-electric Installation at Vizzola.* **A. Luraschi.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 139–171, Aug. 14, 1900.)—This scheme utilises the power developed by a fall of about 90 feet on the river Ticino. The power is mainly supplied to cotton factories, which utilise about 10,000 h.p., the total power available being about 18,000 h.p. The author first describes in some detail the engineering work in connection with the construction of dams, &c. Ten pipes, having an internal diameter of 6 ft. 8 in., are brought into the station, and supply ten turbines of 2,000 h.p. each; two other pipes of 3 feet internal diameter supply two smaller turbines of 220 h.p. each. The larger turbines, at 197 r.p.m., drive triphase generators; the smaller turbines drive continuous current generators at 300 r.p.m., in both cases direct connected. Seven three-phase generators, by the Schuckert Company, have been installed; they give 1,650 kw. at 11,000 volts, with a frequency of 50. The direct current dynamos, used for exciting the main generators and other purposes, give 145 kw. at 110 volts. The voltage of 11,000 was considered the most suitable in view of the fact that the installation is intended to supply power over a radius of about 25 kilometres. A list is given of some of the principal sub-stations which are placed in a large number of towns and villages. At these places, transformers of 200 kw. capacity are installed, reducing the pressure to 3,600 volts; and consumers receive their power at this pressure, and also at a pressure of 125 volts, in case they require it for lighting purposes. The more important consumers have, however, sub-stations on their own premises, where the pressure is reduced to 500 volts. The author concludes by examining various financial aspects of the problems involved in power transmission. The figures given are mainly borrowed from various publications, and cannot conveniently be reproduced in this Abstract. W. H. S.

461. *Electrical Plant in the Transvaal Mines.* **A. W. K. Peirce.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 496–500; Discussion, pp. 501–502, Aug. and Sept., 1900.)—The central mining region, the Witte Water Rand, is supplied with power from a 2,500 kw. three-phase plant, transmitting at 10,000 volts over a pole line 25 miles long. The plant is installed at one end of the district on account of the proximity of coal mines. Branch lines are taken off at intervals along the reef where required, the pressure being transformed down. The porcelain insulators, which are not of high-pressure type, have given trouble by cracking and sometimes exploding. Iron poles, arms, and pins are used, as wood is destroyed by ants. Another three-phase plant of 1,500 kw. in the Central Rand generates direct at 3,300 volts and transmits over five miles. In this case the power is used largely for pumping in the mines, and the high-pressure current is carried down the shaft, in some cases 1,500 feet. The cables are three-core rubber-insulated, lead-covered and armoured, and they give excellent results. The current is transformed and used to drive low-pressure induction motors, usually geared to three-throw pumps. There are several direct-current installations, but such motors are not so satisfactory, owing to the dirt and damp and to the want of intelligent operators. A fairly high-pressure (900 volts or so) was tried for direct-current motors, and also for induction motors, but breakdowns occurred in the insulation.

The principal problem of the immediate future is the application of hoists suitable for shafts of depths ranging to 8,000 feet. This could be done in stages of, say, 3,000 feet, to avoid excessive weight of rope. The hoisting speed usually specified is 3,000 feet per minute, and the load is about 6 tons. The shafts measure 5 ft. 6 in. by 6 ft., and two hoists would probably be used in each shaft. W. H. E.

462. *Power Plant of the Chicago and North-Western Railway Workshops.* (West. Electn. 27. pp. 297–299, Nov. 10, 1900.)—This plant supplies power for the repair shops of a large section of the railway. The boiler-room contains six Babcock boilers of 250 h.p. each, with Roney stokers, working at 150 lbs. per sq. inch. Coal is delivered by rail to conveyors, which deposit it in bins of 180 tons capacity. The engine-room contains two 250-h.p. vertical compound condensing engines, each coupled to two 75-kw. six-pole dynamos, and one 60-h.p. engine coupled to two 20-kw. dynamos for the night-load. The engines were made by the Ball Engine Company, the dynamos by the General Electric Company. The larger engines have cylinders 12 and 22 inches in diameter and 14 inches stroke, and run at 270 r.p.m. The engine-room also contains an air compressor and a hydraulic pump for driving riveters, &c., two fire pumps, and a Cookson feed-water heater. Electricity is distributed on the three-wire system at 230 and 115 volts. The power and lighting circuits are independent, and are supplied by various sets of feeders. Any dynamo can be coupled to either circuit by throw-over switches, and if necessary both circuits can be run in parallel. The motors vary from 1 to 16 h.p., and aggregate 700 h.p. The lighting circuit provides for 100 arc lamps and 2,000 10-c.p. glow lamps. Out of doors the feeders are overhead, and are calculated for a 10 per cent. drop at full load, which, however, rarely occurs. Indoors the wires are rubber-covered and are carried on insulators. To minimise the disturbance due to changing from steam to electric power, most of the motors drive the original line shafting by belt. The buildings cover 100 acres, and 2,000 men are employed. A. H. A.

463. *Electrical Lead-Mining Plant of St. Louis Smelting and Refining Co.* (Electr. World and Engineer, 36. pp. 723–724, Nov. 10, 1900.)—This article describes an electric power and lighting plant at the St. Louis Smelting and Refining Company's mines at Westoge, Mo. Electric hoists are used for raising the ore, electric power drives the crushers, pumps, concentrating jigs, and also the 20-ton locomotives used for handling the ore cars. The plant is noticeable for the use of a large battery of chloride accumulators, which gives 70 to 80 per cent. of the fluctuating load caused by starting a hoist or locomotive, and enables the lighting to be carried out from the power mains without flickering. The plant is worked at 250 volts. Ll. B. A.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

464. *Electric Traction on Railroads.* **K. v. Kándo.** (Zeitschr. Elektrotechn., Wien, 18. pp. 636–639, Dec. 30, 1900. Address before the Society of Engineers and Architects in Buda-Pesth.)—The author contends that the alternate-current solution of this problem is the best. The question is

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

altogether different from the problem of providing power for tramways. The distances and the amount of power required are much greater ; and the load factor is also very different. For instance, on three interurban tramways in the neighbourhood of Buda-Pesth the ratio of the maximum to the mean load on the power stations ranges between 1·7 to 1, and 2·9 to 1. On the other hand, on a line, 15 km. long, running from Buda-Pesth to Vacs, where there is a fairly heavy traffic, similar to that on a railway, the above-mentioned ratio becomes 7 to 1. Batteries can be applied to contribute towards the equalisation of the load on the generators ; but alternate-current transformers can also bear considerable overloads of short duration, and cost far less. The firm of Ganz & Co. went fully into the question when they undertook the reconstruction of certain Italian lines on the border of the Adriatic Sea, which work is now nearing completion. It was then decided to use alternate current, the high-tension current being applied direct to the motors without the intervention of any transformers. Before granting the concession to construct the line from Burgdorf to Thun, the Swiss Government consulted Kapp, Weber, and S. P. Thompson, all of whom reported that high tension was suitable and desirable on the proposed line. Before presenting his report, Weber carried out experiments with a view to ascertaining the voltage dangerous to life ; and he reported that under certain circumstances 100 volts have been known to be fatal, while on the other hand under altered conditions 3,000 volts do not necessarily constitute a fatal shock. The author considers that under present railway conditions any advantages derived from increasing the voltage beyond 3,000 or 5,000 volts are outweighed by the increased difficulties of insulating the motors, and of constructing high-tension apparatus generally. The great objection to the alternate current lies in the distrust felt for high-tension current, in that it is possible for it to be dangerous to life. A shock can only result through failure of insulation, and then only supposing the current to leak away through bodies which are bad conductors in themselves, or are connected to earth through bodies having high resistance. This being the case, it is merely necessary to completely surround all conductors carrying high-tension current at all places by a continuous metallic sheath, and on the cars this metallic sheath must be directly connected in several places with the truck, and so with the wheels and rails. The carriage roofs must also be similarly connected to the wheels. The only piece of apparatus requiring manipulation is the motor switch, and this must be enclosed in a cast-iron case, and by interlocking arrangements it should be impossible to open the case unless the current has been previously switched off. At the various stations, the current should always be switched off the line, unless a train is either about to arrive or depart ; and various precautions of a similar nature are mentioned. A slightly different solution of the problem lies in reducing the pressure by means of transformers carried on the trains ; but this is not to be regarded as a satisfactory solution, seeing that it increases the weight of the train, and so does away with one of the chief advantages of electric traction which lies in the fact that the weight of the motors is small. Transformers might easily increase the weight of the train by 10 or 20 per cent. W. H. S.

465. *Automobile Batteries.* **E. Sieg.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 183–186, May 15, 1900.)—The general properties that an accumulator should possess in order that it may be suitable for traction work are considered. As a basis of calculation it is assumed that a vehicle for four persons, each of 75 kg., or 0·3 ton (German) has when loaded a total weight

', whilst the motor weighs W/10, and the empty vehicle is 2/3 the weight of
e passengers, battery, and motor, or—

$$W = 0{\cdot}3 + B + W/10 + 2/3\,(0{\cdot}3 + B + W/10),$$

hich becomes— $$W = 0{\cdot}6 + 2B. \qquad (1)$$

Assuming a motor efficiency of 70 per cent., and a speed of 18 km. an hour,
5 m. per second on the level, with a traction coefficient of 25 kilos per ton,
en the power E required is—

$$E = \frac{W \times 5 \times 25 \times 100 \times 736}{70 \times 75} = 1750W \text{ watts.}$$

If the vehicle is required for a three-hours' service, corresponding to about
run of 50 km., then the capacity C of the battery in watt-hours will be—

$$C = 3 \times 1750W = 5250W \qquad (2)$$

$$C = 1000Ba \qquad (3)$$

here a = the watt-hour capacity per kilo for a three-hours' discharge of
e battery. Hence from (1), (2), and (3)—

$$B(a - 10{\cdot}5) = 3{\cdot}15 \qquad (4)$$

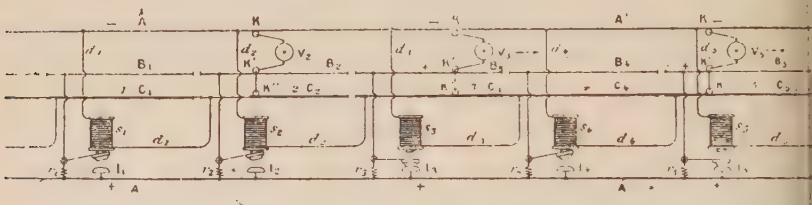
hich gives the limiting value of a as 10·5 watt-hours, or with a mean pressure
1·9 volts, 5·5 ampere-hours.

If B be 700 kg., then 8 ampere-hours per kilo of battery will be necessary.
or stationary cells the capacity varies from 3–5 ampere-hours per kg. The
thor then considers the possible means of making automobile cells with the
uch greater specific weight-capacity demanded. W. W. H. G.

466. *Automatic Electric Carrier.* (Écl. Électr. 24. pp. 390–393, Sept. 8,
00. From a paper read before the Société Scientifique et Industrielle de
arseille, May 17, 1900, by H. Dubs and L. Laffitte.)—H. Dubs and L. Laffitte
ve designed a high-speed automatic electric carrier, intended to take small
rcels or letters. Their system comprises a double track carried on a
aduct, with motor-vehicles and control apparatus. The track is laid with rails
eighing 12 kg. per metre to a 70-cm. gauge with conducting rails carried on
sulators fixed to the sleepers. The track is protected from the weather by a
ntinuous iron roof. The viaduct is about 3 m. above-ground. The vehicles
e sheet-iron boxes with 2 or 4 axles and 60 cm. wheels. The motors are
ound on the axles themselves, and when running at 2,200 r.p.m. give a speed
250 km. per hour. Current is picked up by three shoes in duplicate in the
ont and at the back. The vehicles are 6 m. long, torpedo-shaped, and com-
ise a central compartment for goods and a compartment at each end for the
tomatic regulating apparatus. Gradual starting is effected by a centrifugal
gulator, which cuts out resistance in the armature circuit as the speed
creases. When current is cut off the regulator reinserts the resistance ready
r starting. Stopping is effected automatically by brake blocks on each wheel,
hich are only held off when current is passing through a controlling sole-
id. The line is divided into sections proportional to the headway between
e vehicles. Current is supplied to the shoes KK′ by a continuous rail
′ and a sectional conductor $B_1, B_2, \ldots B_n$, which is itself fed from a fixed
nductor A through interrupters $I_1, I_2 \ldots I_n$. A second sectional conductor
$C_1, C_2 \ldots C_n$ is provided parallel with $B_1, B_2 \ldots B_n$. Each vehicle carries
ree shoes, K rubbing on A′, K′ on B and K″ on C, K′ and K″ being electri-

cally connected. When no vehicle is on the line, all the interrupters I_1, I_2 . . . I_n are closed and B_1, B_2 . . . B_n are connected to A. If a vehicle comes on to section 5, a current passes through A, I_5, B_5, K′, K″, C_5, d_4, s_4, d_4, A′ and opens the interrupter I_4, so that no vehicle can overtake the one on section 5. If the momentum of a vehicle V_2 has carried it from an active section 1 on to a dead section 2, the interrupter s_1 will be opened by current round s_1 through A, r_2, B_2, K′ K″, C_2, d_1, s_1, d_1, A′, and the vehicle will stop on section 2, the resistance r_2 being such as to allow sufficient current to pass to operate the interrupter, but not enough to hold off the brakes.

The above description assumes the use of continuous currents, but actually



three-phase currents and asynchronous motors have been used, thereby securing almost constant speed as well as avoiding commutators and brushes, without unduly complicating the connections. The inventors calculate that the power required to move the vehicles at 250 km. per hour will be about 45 h.p. on the level and 60 h.p. on a 2 per cent. grade. They propose generating stations at distances of 40 to 50 km., the maximum safe voltage at the motors being 300 volts. E. H. C.-H.

REFERENCE.

467. *Electricity Applied to Mining.* **H. Bentham.** (Elect. Engin. 25. pp. 669–672, May 11 ; and 695–697, May 18, 1900. Paper read before the Manchester Society of Junior Electrical Engineers.)—This is a general description of the problems arising in coal-mining work, and gives details of methods in actual use applied to a particular case, and also gives a detailed estimate of comparison of first cost and working costs of steam and electric plants respectively, showing, after allowing 5 per cent. interest and 10 per cent. depreciation, a balance of £303 per annum in favour of electric working on a 1,000-h.p. plant. Ll. B. A.

TELEGRAPHY AND TELEPHONY.

468. *Woolley's Magneto-Electric Telegraph System.* (Elect. World and gineer, 36. pp. 858–859, Dec. 1, 1900.)—This is an invention of L. G. ɔolley for operating fire alarms, telegraphs, railroad semaphores, fog signals, . The transmitter consists of a magneto-generator whose armature is under ıstant spring tension. The tension is released by the operation of a ınmon transmitting key. When the key is pressed and released each ɔvement lets the armature fly through half a revolution, and it gives a ·rent in each case of opposite polarity. The sudden stopping of the nature gives a current of high pressure. These currents being received a polarised relay can be utilised for any of the purposes intended. The ventor has devised a field service telegraph worked with his transmitter tead of a battery; the receiver is in a light metal box strapped to the dy; the relay armature oscillates and taps upon a diaphragm, and from s latter rubber tubes proceed to the ears. In fire alarm work the armature of e magneto-generator is operated and controlled by clockwork. The receiving ay at headquarters controls the mechanism of a mechanical gong on which e alarm is sounded, at the same time a record of the signalling box number made on a tape run through a recording instrument, which is set in motion secondary impulses. The lines are at regular intervals under test auto- ıtically, and should abnormal conditions occur the fact is made known by e sounding of a gong. E. O. W.

469. *Cable Speeds.* **J. E. Young.** (Electrician, 46. pp. 89–92, Nov. 9, 00.)—Speed of signalling is determined primarily by the constants of the ble as affecting wave-propagation and wave-form. It is further limited by e degree of efficiency of curbing devices, or of similar apparatus used for e purpose of shaping the impulses. Finally, it depends upon the degree of nsitiveness of the receiving apparatus. By extending Kelvin's diffusion eory to include inductance and leakage, Heaviside has been able to in- stigate the general case of cable speeds. The writer points out certain fferences of nomenclature existing between Heaviside and custom. Thus e letter K, which generally denotes electrostatic capacity, is used by eaviside for the "leakage conductance," whilst his symbol for "static pacity" or "permittance" is S. Thus Heaviside's line-constants are = conductor resistance, S = capacity, I = inductance, and K = leakance. ıe condition of the "distortionless circuit" is L/R = S/K, but in practice is is never attained. The electromagnetic time-constant is the ratio of nrys to ohms, *i.e.*, seconds. Approximately, it is the quantity which would termine the rate of the electromagnetic discharge, or "extra current," if ere were no electrostatic capacity in the circuit. The usual electrostatic me-constant, the "KR" of commerce, is expressed in seconds, ranging from ıe to ten for submarine cables. It is the time governing the rate of the atic discharge in the absence of counteraction by electromagnetic capacity inductance. If the capacity were all at one cross-section of the cable and scharged through the resistance of the conductor, this latter "KR" would the time in which the cable would lose 63·2 per cent. of its charge. The her electrostatic time-constant is the product of megohms and microfarads,

and for well-insulated cables is generally of the order of minutes. It is the interval in which the cable loses 63·2 per cent. of its charge by leakage through its dielectric, were it not for the action of absorption. Heaviside shows that when the magnetic is one-third of the static time-constant the impulsive inductance balances the impulsive capacity, if we neglect distribution and leakage. Again, whilst the first static time-constant, RS, varies as the square of the length of the cable, the second static and the magnetic time-constants are independent of it, so long as I is the natural inductance, either of a land line or of the conductor and sheathing wires of an uncoiled cable. It appears likely that S varies with the frequency. In the case of siphon recorder signals, very little increase of speed is to be derived from any arrangement of isolated leaks. If, however, a cable is to be worked much below its maximum recorder speed, then one or more leaks may prove of value by discharging the line rapidly and by increasing the definition. In considering the method of reducing distortion by increasing the inductance, the author refers to the experiments of Breisig and of Pupin, and points out that whilst the interposition of inductance at a single position in the cable occasions wave reflections when the wave-length is less than that of the cable, its distribution at multiple points does so to a decreasing extent as the number of coils is increased up to a certain limit, beyond which there is no appreciable advantage. R. A.

470. *Magnetised Coherer.* **C. Tissot.** (Comptes Rendus, 130. pp. 1386–1388, May 21, 1900.)—The magnetised coherer [see Abstract No. 1617 (1900)] is used in connection with apparatus at Portzic lighthouse, and signals were exchanged with a battleship at a distance of 61 km. The author emphasises the advantage of desiccating the filings and the coherer tube, so that the electrodes and filings may always be bright. It is found of great value to be able to adjust the "critical tension" of the coherer contacts by means of the magnetic field. The resistance unmagnetised may be 500,000 ohms, but by magnetisation this can be brought down to between 1,000 and 2,000 ohms. In the present instance, for example, the relay refused to work when the coherer resistance was 3,000 ohms, but it worked excellently when this was adjusted by magnetisation to 1,500 ohms, *i.e.*, to the "critical" condition. R. A.

471. *Syntony in Wireless Telegraphy.* **A. Blondel.** (Comptes Rendus, 130. pp. 1383–1386, May 21, 1900.)—According to the experiments of Bjerkness and the theory of Poincaré, the oscillations at the emitter are so quickly damped that there is no possibility of establishing true resonance at the receiving station, so that methods of selection must be regarded as empirical. In 1898 Blondel deposited with the Académie a paper entitled "Perfectionnements à la télégraphie sans fil," in which is described a method of obtaining syntony, not between the oscillator and the receiver, but between two artificial frequencies, using a selective telephone. Instead of the Morse apparatus and relay generally adopted, the suggestion was to employ a vacuum tube in series with a telephone and a battery, the normal potential difference being just too low to permit a discharge to traverse the tube, but sufficient to produce a current at each impulse from the oscillator. The telephone responds to each emission from the sending station, and the tone is determined by the number of discharges per second from the emitter. At short distances the vacuum tube is unnecessary. By varying the frequency at the emitter it is possible to differentiate between various stations, and by

e employment of appropriate telephones a selective system is obtained. A issler tube should be used, with broad electrodes almost in contact.

A tuning device, consisting of a condenser and inductive resistance, may be plied at the receiving end, the best values for which, for a given frequency, n be easily calculated by the "pendulum" formula. R. A.

472. *Vienna State Telephone Exchanges.* **H. Dreisbach.** (Elektrotechn. itschr. 21. pp. 864–869, Oct. 18; and 883–887, Oct. 25, 1900.)—In these pers are described the two new exchanges of the Vienna State telephone stem. They are designed for 12,000 subscribers with complete metallic rcuits, using the Western Electric Company's multiple switch with incan-escent-lamp indicators. The cost of the buildings was 755,000 M. and 5,000 M. respectively; of the technical arrangements at the same two ildings 1,090,000 M. and 508,000 M. respectively, and at a secondary change-office, 60,000 M.; of the connections between the existing network d the exchanges, 94,000 M., for the cement conduits (Hultmann's system, e Elektrotechn. Zeitschr. 1898, No. 7), and 821,000 M. for the cables. The pers are illustrated by a large number of drawings and photographs giving tails of the buildings, instruments, and conduits, together with diagrams of nnections. C. K. F.

473. *Magneto-Telephone Signals.* **N. H. Holland.** (Elect. World and ngineer, 36. pp. 782–785, Nov. 17, 1900.)—After giving some historical notes, e author goes on to describe the following as a very promising form: etween the two horseshoe magnets a coil is supported by a strong flat spring. ne coil has a handle which permits the coil to be pulled to one side and then lowed to swing back, whereby currents are generated. An armature of the emens type rotated between the prongs of three or four horseshoe magnets the generator that has been found best suited to meet all the requirements telephone service. A standard three-magnet generator, when carefully ade, will have an output of about 5 watts at a pressure of 80 volts and an mature speed of about 1,500 r.p.m. In Gray's patent of 1884 a generator shown in which the fields are composed of electromagnets energised by the cal battery. A number of different styles of polarised bells have been used, it nothing has yet equalled that form in which the armature is centrally voted in front of the electromagnets. Methods suggested for using a local ttery for ringing polarised bells by means of an induction coil and vibrator ve met with but little success. J. E. K.

474. *Wireless Telephony.* **W. H. Preece.** (Elect. Rev. 47. pp. 484–485; iscussion, pp. 485–486, Sept. 21, 1900. Paper read before the British Asso-ation.)—The first experiments were made in February, 1894, across Loch ess, using two parallel wires, earthed at each end, one on each side of the ke. When the length of each wire was 4 miles, it was found possible to change speech across the Loch, at an average distance of 1·3 miles. In 1899 was proved by experiment at the Menai Straits that the maximum tele-nonic effect is produced, other things being the same, when the parallel res are terminated by "earth" plates in the sea itself. A wire 750 yards in ngth, parallel to another 3½ miles in length, with "earth" plates in the sea, abled telephonic speech to be maintained across a distance of 2·8 miles. milarly speech was transmitted by Gavey between Rathlin Island and the ainland of Ireland.

Discussion.—**O. Lodge** said he always held that conduction between the opposed circuits was a more important factor than the induction between the wires, although the two helped one another and went in the same direction. In some cases it might be possible that induction was the more powerful. With induction stronger currents could be developed, tuning was better and resonance more effective than with conduction. One reason why the telephone and high-frequency currents are so efficient arises from the fact that such currents do not spread in three directions. The conductivity of the earth is sufficient to keep high-frequency currents near the surface, so that they are more or less restricted to two dimensions. **J. West** pointed out that as regards these systems as applied to signalling between two ships at sea, he found that the parallelism of the induction wires was of great importance; ships at right angles to one another cannot transmit signals by this method. **W. H. Preece** emphasised the need for eliminating self-induction from the circuits, and in general to make the impulse as abrupt in rise of potential as possible. R. A.

REFERENCES.

475. *Telephone System at Pittsburg.* **K. B. Miller.** (Elect. World and Engineer, 36. pp. 671–675, Nov. 3, 1900.)—Description of independent exchange with switchboard on Kellogg central battery system, using two contacts on the plug and two strands in the cord. J. E. K.

476. *The Telegraphone.* **V. Poulsen.** (Electrician, 46. pp. 208–210, Nov. 10, 1900.)—A description of the instrument referred to in Abstract No. 1973 (1900).

477. *Wireless Telegraphy.* **A. Blondel** and **G. Ferrié.** (Écl. Électr. 24. pp. 471–475, Sept. 22; and 491–499, Sept. 29, 1900. Paper read before the International Electrical Congress at Paris. Abstract in the Electrician, Oct. 26, 1900.)—This is a review of the history of wireless telegraphy, both as regards apparatus, theory, and results. R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1901.

GENERAL PHYSICS.

478. *Density of Solid and Liquid Carbon Dioxide.* **U. Behn.** (Ann. d. Physik, 3. 4. pp. 733–743, Dec., 1900.)—For the density of solid carbon dioxide at $-79°$ and under a pressure of 1 atmosphere the author gives the mean value 1·53, the extreme limits of the six numbers obtained being 1·512 and 1·548. The apparatus employed consists of a vacuum-jacketed graduated tube, which is about half filled with ether, the latter then being saturated with carbon dioxide and cooled somewhat below $-79°$. After the volume and weight of the ether have been determined, solid carbon dioxide is introduced in such quantities that it is just covered by the ether, and the increase in weight and volume of the ether then measured. Using the same apparatus, control experiments with various salts and their saturated solutions gave good results. For measuring the density of the liquid the method employed consists in passing the compressed gas from a steel cylinder first through a tube containing cotton-wool plugs and then into a glass tube in which it condenses and which contains glass floats of varying densities; this tube is surrounded by a vacuum-jacketed vessel containing alcohol, which is cooled to the desired temperature by means of solid carbon dioxide and is kept well stirred. The numbers obtained are contained in the following table, which gives the density of the liquid carbon dioxide under the pressure of its saturated vapour :—

Temperature.	Density.	Difference for 1°.
$+30°$	(0·598)	(0·0470)
$+20$	0·772	(0·0108)
$+10$	0·860	0·00735
0	0·925	0·00602
-10	0·981	0·00525
-20	1·031	0·00468
-30	1·075	0·00422
-40	1·116	0·00392
-50	1·154	0·00374
-60	1·191	0·00367

The numbers in brackets are taken from the results of Amagat, given in the Comptes Rendus, 114. p. 1093 (1892), which agree well with the author's

measurements. The values given in the third column of the table, representing the diminution in density caused by a rise of temperature of 1°, show that at the freezing-point this diminution has about the same value as for the gas; as the temperature rises its value increases, at first slowly, but with increasing speed as the critical temperature is approached when it becomes infinite. T. H. P.

479. *Expansion of Water.* **M. Thiesen, K. Scheel,** and **H. Diesselhorst.** (From Wissensch. Abhandl. d. Phys.-Techn. Reichsanstalt, 3. pp. 1–70; summary by Dr. Scheel in Zeitschr. Instrumentenk. 20. pp. 345–347, Dec., 1900.)—Determination of expansion by a method based on communicating columns. Precautions, apparatus, &c., are described. At temperature $t°$ C. the density of water is found to be—

$$1{\cdot}00 - \left(\frac{(t-3{\cdot}98)^2}{503570} \cdot \frac{t+283}{t+67{\cdot}26}\right).$$ A. D.

480. *Surface-tensions of Liquids and Melted Metals.* **L. Grunmach.** (Ann. d. Physik, 3. 4. pp. 660–671, Dec., 1900.)—The author describes the method he has employed, viz., that of "capillary ripples." For details reference must be made to the original paper. The following table, in which the numbers denote the surface-tensions in grammes per centimetre at 20° C., gives the results obtained with pure liquids:—

	Method of Ripples.	Method of Capillary Elevation.
Mercury	0·400	—
Water	0·075	0·074
Ethyl Alcohol	0·027	0·029

The numbers given in the second column were obtained by the "Normal Aichungs-Commission." [See also Abstracts Nos. 1315 (1899) and 17 (1901).] F. G. D.

481. *Mechanical Action of Sprengel Pump.* **H. Boas.** (Deutsch. Phys. Gesell., Verh. 2. 17. pp. 246–248, 1900.)—When a Sprengel pump is used to exhaust a vessel the mercury columns in the fall tubes are seen at first to be broken by short columns of air, but as the exhaustion proceeds these air columns become shorter and shorter until they finally disappear. The exhaustion still progresses, however, and in the present paper the author shows that the mechanical action of the pump at these very low pressures is similar to its visible mechanical action at the higher pressures. By instantaneous illumination of the fall tubes by means of an electric spark the mercury column is seen still to be broken by layers of air filling the whole section of the tube, but owing to the high velocity of the mercury and the thinness of the layers the appearance presented to the eye with ordinary illumination is that of a continuous column. An instantaneous photograph of the columns of a six-fall Sprengel pump is given in the paper. J. B. H.

482. *Graphical Representation of Mean Square Values.* **E. Brisse.** (Écl. Électr. 25. pp. 488–492, Dec. 29, 1900.)—If V denote the effective value of an alternating periodic function e whose period is T, then by definition—

$$V^2 . T = \int_t^{t+T} e^2 dt$$

Now if we suppose the curve e drawn in a plane and from every point of

ne curve we draw lines perpendicular to the plane whose lengths are equal the ordinates at the points, then if from the extremities of these lines we raw perpendiculars on the axis of t we get a wedge-shaped prismatic solid hose volume is half the value of the above integral. This construction in ome cases gives us an easy method of finding effective values. For example, can be seen graphically that if we have—

$$v_1 = a + c$$

here a is a constant, then—

$$V_1^2 = a^2 + V^2$$

here V_1 is the effective value of v_1. A theorem is given which enables the ffective value to be at once found when the wave is a symmetrical trapezium, triangle and a square being limiting cases of this trapezium. A. R.

483. *Wöhler's Laws.* **J. Gilchrist.** (Engineer, 90. pp. 203–204, Aug. 31, 900.)—The author discusses some of Wöhler's experiments, and is of opinion hat the fracture was caused by the statical breaking limit being exceeded at ne point only, from which rupture once started would spread at first rapidly nd afterwards more slowly, and that the raising of stress at the point where racture begins is due to an irregularity or flaw in the bar. That the same ause would not operate in the ordinary breaking of the same bar in a testing nachine he attributes to the fact that the greater speed of loading in the Wöhler machine causes the bar to behave in a harder manner. H. R. C.

484. *Motions of the Ether.* **W. Wien.** (Phys. Zeitschr. 2. pp. 148–150, Dec. 8, 1900.)—Wien makes two principal objections to Mie's work on this ubject. Firstly, Mie maintains that Helmholtz's hypothesis of an inertia-less ther is inconsistent with the fact that Poynting's Vector possesses vortices. Wien contends that although Helmholtz's hypothesis leads to difficulties, it is ot because of the existence of these vortices. Writing P, Q, R for the omponents of Poynting's Vector, and ξ, η, ζ for $\frac{dQ}{dz} - \frac{dR}{dy}$, &c., Wien leduces equations showing that when ξ, η, ζ are everywhere zero, $\frac{d\xi}{dt}$, $\frac{d\eta}{dt}$, nd $\frac{d\zeta}{dt}$ are all zero; and therefore ξ, η, ζ, if ever simultaneously zero at all oints in space, must ever remain so. Nevertheless, in general ξ, η, ζ do not imultaneously vanish at all points, though Wien shows we can imagine a ystem in which that is the case.

Wien next considers Mie's conclusion that certain experiments necessarily ead us to expect that currents exist in the ether. Wien contends, and gives special example to prove, that a system may exist in which the electric and nagnetic forces may be at right angles to each other, but in which Poynting's ector has no vortices, and therefore in general no ether current is necessary. S. H. B.

485. *Motions of the Ether.* **G. Mie.** (Phys. Zeitschr. 2. pp. 181–182, Dec. 22, 1900.)—This paper is a reply to Wien's remarks [see preceding Abstract]. With regard to the first objection the author understands Wien's meaning to be that examples should have been given of the Poynting Vector possessing vortices changing with the time. Such examples, says the author, giving an instance, are easily constructed, but were omitted from his work for the sake of brevity.

He considers further that there must be some misunderstanding between himself and Wien as to the import of his (Mie's) integrals of the equations of motion for the ether. These Wien asserts to be merely possible integrals. Mie maintains that they are the only possible integrals consistent with all Helmholtz's assumptions.

Finally he regards it as an admitted theorem that in a statical field Poynting's Vector must possess vortices, and maintains that the special example which Wien gives to the contrary fails to disprove it, because in that example vortices must occur at the bounding surface of the field.

S. H. B.

486. *Law of Action of the Internal Forces of a Body.* **H. Petrini.** (Ann. d. Physik, 3. 4. pp. 749–752, Dec., 1900.)—The writer here investigates the conditions that the force between two neighbouring elements of a continuous homogeneous substance shall never become infinite. He assumes the potential of mutual action of the elements to be $d\mathrm{T}d\mathrm{T}'\phi(r)$, where $d\mathrm{T}$ and $d\mathrm{T}'$ represent the elements, and r their distance apart. As the result of the mathematical investigation, he obtains the condition required in the form that $\int_0^a r^2\phi(r)dr$ must be finite for any positive value of a.

It is necessary to assume (1) that if β be any numerical quantity greater than unity, then, in the limit, when $r=0$, $\frac{\phi(\beta r)}{\phi(r)}$ is positive. The writer also does assume, though not, as he says, of necessity, (2) that if $r'>r$, then $r'^2\phi(r')/r^2\phi(r)$ is less than a certain finite quantity. If $\phi(r)$ be a negative power of r, for instance, $\phi(r)=\frac{c}{r^{3-\rho}}$, where ρ is positive, then the force is of the form $\frac{c'}{r^{1+\rho}}$. Whence it follows that Cauchy's hypothesis that the law of forces is the inverse fifth power of r cannot apply to continuous substances.

S. H. B.

487. *Temperature Variations in Higher Atmospheric Strata.* **L. Teisserenc de Bort.** (Comptes Rendus, 131. pp. 920–922, Nov. 26, 1900.)—Continued observations confirm the opinion that the changes of temperature with the seasons decrease in amplitude at high elevations, but that they are still very distinct at altitudes of 10 km.; while the mean monthly values on the surface of the globe show an annual variation of 17°, the variation at an altitude of 5 km. amounts to 14·6°, and at 10 km. to 12°. The zero isothermal is at an altitude of 1,200 m. at the end of winter, and at 3,600 m. in summer; the annual mean of 2,750 m. corresponds with the boundary line of snow in the Alps. The maxima and minima of the higher strata lag behind those of the lower strata; this is particularly striking in the case of the minima which, in the higher strata, fall in March. May is colder than April, and this relapse is quite as pronounced for the isothermal — 50° (whose altitude varies between 8,700 and 11,400 m., according to the season) as for the isothermal 0°. [See further Abstract No. 1843 (1899).]

H. B.

488. *Periodical Variations in Glaciers.* **F. A. Forel.** (Archives des Sciences, 10. pp. 401–417, Nov., 1990. Paper read before the Société Helvétique des Sciences Naturelles, Thusis, Sept., 1900.)—Since 1881 the author has published yearly reports on the Swiss glaciers. The variations of glaciers are not merely changes in form, but real changes in volume, which

m, as a rule, be determined by measuring the length. There is a yearly riation, and further a period covering about a third of a century (thirty-ve years, E. Brückner and E. Richter). The author used to assume that the eriod of growth lasted on an average 10·5 years, and the period of diminu- on 27·4 years, giving a cycle of 37·9 years. But the matter is not so simple. he growth does not commence in the same year for all the glaciers of a strict, because their snow-feeders are different. A diminution sets in multaneously for the various glaciers with a hot summer, whose effect tends over several seasons; the stoppage of the feed also causes a minution. The minimum volume of a glacier must be regarded as its ormal size. But every glacier has its own character. H. B.

489. *Distant Thunderstorms observed by the Electro-Radiophone.* **T. ommasina.** (Comptes Rendus, 131. pp. 876–878, Nov. 26, 1900.)—The uthor has used his improved carbon coherers [Abstract No. 1295 (1900)] as lectro-radiophones for the purpose of detecting thunderstorms too distant to etect in other ways. The electrodes are not metallic, as in earlier forms, t consist of lamp carbons joined to platinum wires; the coherer is ermetically sealed to exclude all moisture. His laboratory on Lake aggiore is 6 m. above the soil; three copper antennæ, each 30 m. long, ere fixed to insulators at a height of 12 m., and one end of each was con- ected to earth. The antennæ were not fixed vertically, as this position ould have rendered the experiments too dangerous, and were completely sconnected and carefully insulated on the approach of a thunderstorm. H. B.

490. *Meteorological Observations during a Petroleum Fire at Bayonne, N.J., uly 5, 6, 7, 1900.* **W. H. Mitchell.** (Monthly Weather Rev. 28. pp. 5–327, Aug., 1900.)—At midnight, July 4–5, lightning struck and exploded me oil tanks of the Standard Oil Company. By seven next morning the nes within half a mile around marked a draught towards the fire. There was t little wind, and the umbrella-shaped smoke column attained a height of ,411 feet, measured by triangulation. Above that dark column white ouds formed and remained visible for two days in an otherwise cloudless y. The explosion of three tanks at 10 a.m. on July 5, produced a whirl- ind lasting five minutes; in the evening a gas oil tank exploded, the flames ooting up 3,000 feet. The heat of these flames was felt at a distance of miles, and was more noticeable at that distance than close to the fire. ocal thunderstorms about 4 p.m. on July 6 and 7, possibly connected with e fire, destroyed the smoke column, which disappeared on July 8. Sixteen nks, each of 30,000 gallons capacity, containing various oils, wax, and tar, ere destroyed. H. B.

REFERENCES.

491. *The Reichsanstalt, Charlottenburg.* **H. S. Carhart.** (Amer. Inst. ect. Engin., Trans. 17. pp. 469–487, Aug. and Sept., 1900.)—A general description the buildings, and of the nature of the work undertaken.

492. *Chemical Composition of Celestial Bodies.* **A. Ditte.** (Revue Scientif. 14. . 609–618, Nov. 17, 1900. Lecture delivered at the University of Paris, Nov. 7, 00.)—This paper is a concise review of the present knowledge of the chemical nstituents of the various cosmical bodies, as determined from spectroscopic alysis. C. P. B.

LIGHT.

493. *On a Property of a System of Wave Normals.* **A. Gleichen.** (Deutsch. Phys. Gesell., Verh. 2. 17. pp. 249–252, 1900.)—The case considered is that of a wave of light passing out of a refracting medium. Consider an element dS of the wave surface. Corresponding to it are two foci, F_1 and F_2, in the wave normal. The distance F_1F_2, known as the "astigmatic difference," is 2Δ. If a section be formed at F between F_1 and F_2 of the pencil of rays which passes through the element of wave surface dS, F_1 and F_2 are on opposite sides of it, the surface being antielastic, and if r_1 r_2 be its principal radii of curvature, $F_1F_2 = r_1 + r_2$. Let λ be the area of the section at F; λ has its maximum value when $FF_1 = FF_2 = \frac{1}{2}\Delta$.

The point F is defined as the "pole" of the pencil. It has the property that at the pole the curvature of the section is a minimum and its area a maximum. If the radiation from an element dq of wave surface in a cone whose solid angle is ω and direction a, be $E = cdqf(a)d\omega$ where c is constant, the intensity at a point in the pencil where the section is λ is $J = E/\lambda$. Let J_0 be the value of J when this section is distant $\sqrt{\Delta^2 + 1}$ from the pole, so that its principal radii of curvature are $\sqrt{\Delta_2 + 1} + \Delta$ and $\sqrt{\Delta^2 + 1} - \Delta$. Then the value of J for a point distant r from the pole is $J = J_0/(r^2 - \Delta^2)$. If $\Delta = 0$, or the pencil is one of ordinary light, J varies as $-\frac{1}{r}$. S. H. B.

494. *Application of the Fourier Expansion to Optics.* **C. H. Wind.** (Phys. Zeitschr. 2. pp. 189–196, Dec. 29, 1900.)—The author supposes that at a point Q a disturbance takes place, concerning which nothing is assumed except that it may be represented by a vector, of which we may study each component separately. If this vector be a function of the time, $f(t)$, we are to consider its value during a finite time T commencing from $t = 0$: $f(t)$ can then be expanded in the Fourier series,

$$f(t) = \frac{1}{T}\int_0^T f(t)dt + \sum_{n=1}^{n=\infty}\left(A_n \sin n\frac{2\pi t}{T} + B_n \cos n\frac{2\pi t}{T}\right)$$

Here—

$$A_n = \frac{2}{T}\int_0^T f(t)\sin n\frac{2\pi t}{T}dt$$

$$B_n = \frac{2}{T}\int_0^T f(t)\cos n\frac{2\pi t}{T}dt$$

If it is allowable to assume that during the interval T, positive and negative values of $f(t)$ are equally represented, the term $\frac{1}{T}\int_0^T f(t)dt$ vanishes. If this assumption is not allowed, then the alternative assumption will be made that $f(t)$ vanishes for $t = 0$, and for $t = T$.

To each member of the Fourier series corresponds a particular vibration. The vibrations which take place during the interval T are not independent of those which immediately preceded that period, nor of those in the imme-

ately succeeding time. Nevertheless, we may consider a period T′ lying within T, such that the influence of the state of the system before and after on its state during T′ shall be inappreciable, and also so that the differences between T and T′ at either end may be neglected. This is on the assumption, which is legitimate, that T is very great compared with the time of the passage of light through our apparatus. And this assumption being made, it matters not what the state of the system was before T, or will be after T. We may then treat the observed phenomena as represented by an uninterrupted succession of the harmonic terms in the Fourier series.

After discussing the nature of the apparatus, the writer concludes that whether observations are made with the eye or with the photographic plate, we can observe, not separate waves, but only the time average of a number of consecutive waves. The observed vector at P, which corresponds to the disturbance at Q, will then have the form

$$E = \tfrac{1}{2} C \sum_{n=1}^{n=\infty} \Omega_n (A_n^2 + B_n^2),$$

where Ω_n is a function of n whose form depends on the position of P and the nature of the apparatus. For any given apparatus this will generally give different results for different kinds of waves. But this difficulty can be overcome by substituting for the constant C a function γ_n of n, which vanishes for very small values of n, so that the intensity at P is given by

$$B = \sum_{n=1}^{n=\infty} \gamma_n \Omega_n (A_n^2 + B_n^2).$$

The results are as follows: In order to calculate the radiation at any point P in the field, we have first to fix a point of time t_0 at which the radiation in question was emitted from Q; next to choose an interval of time T, such that t_0 is approximately its middle point, and which is the greatest value which has the property that phenomena following each other at an interval less than T are with our apparatus indistinguishable from each other. T being so chosen, we have to take the Fourier series, which expresses the disturbing process during T, and calculate the mean value of $A_n + B_n^2$ for every $\frac{n}{p}$ consecutive values of n, where p is a very great number, so that $1/p$ represents the time of passage of light through the apparatus. That gives an energy curve which we may call the energy curve of the source at time t_0. This energy curve is the only measure of the influence of the disturbance at Q on the observed phenomena. Independently, then, of the uncertainty attending the coefficient γ_n, we cannot determine the separate coefficients of the Fourier series. The utmost we can do is to construct an energy curve which shows the mean values of the squares of the amplitudes for a great number of consecutive terms of the Fourier series.

The writer discusses in a note, on p. 191, Sommerfeld's theory of impulses [Phys. Zeitschr. 2. pp. 55–60, Oct. 27, 1900. Abstract No. 364 (1901)]. S. H. B.

495. *Ultra-violet Absorption.* **B. Glatzel.** (Phys. Zeitschr. 2. pp. 173–178, Dec. 22, 1900.)—The absorption of ultra-violet light in an alcoholic solution of benzol is much less than the absorption in metals. Alcoholic solutions of anthracene and retene have very high coefficients of absorption, which come up to and even exceed those of all metals except silver. The power of

reflexion of metals, as in the visible spectrum, falls off in the ultra-violet with decreasing wave-lengths, except in the case of silver, which has a minimum reflecting power at $\lambda = 322\mu\mu$. The power of reflexion of anthracene and retene for ultra-violet light is not nearly as great as that of the metals; which leads us to suppose that these hydrocarbons are much less absorbent when solid than when in solution, as the mechanical theory of absorption would itself indicate. [See further Abstract No. 1786 (1900).] A. D.

496. *Persistence of Vision.* **F. Allen.** (Phys. Rev. 11. pp. 257–290, Nov.–Dec., 1900. Paper read before the American Association, N.Y., June 27, 1900.)—The author has made numerous experiments to determine the effect upon the persistence of vision of exposing the eye to light of various wave-lengths, and exhibits the results by curves in which ordinates represent the persistence of vision for various parts of the spectrum in seconds, and abscissæ are wave-lengths. The following is the summary of the results arrived at:—

(1) The persistence of all colour impressions reaches a maximum when the eye has been kept open in the dark, the increased duration being unequal for rays of different refrangibilities. The increase is least in the yellow, and grows larger towards both the red and violet. The curve obtained under such conditions may be called the *extraordinary* normal curve.

(2) The persistence of all colour impressions is a minimum when the eye is under the influence of diffused daylight. The curve thus obtained is termed in this paper the *ordinary* normal curve.

(3) When the eye has been blindfolded, the values of the persistence in all cases are intermediate between the extraordinary and ordinary normal curves, showing, however, unequal increases as in the extraordinary curves.

(4) When the retina has been exposed to strong red, green, or violet light, the persistence of impressions of the same colour as the fatiguing light is increased, forming a characteristic elevation or bunch in the part of the persistency curve corresponding to that colour.

(5) When the retina has been fatigued with yellow or blue light, there is no increase in the persistence of impressions of those colours, but the characteristic elevations are produced in the parts of the curves corresponding to red and green or green and violet respectively.

(6) These phenomena confirm the Young-Helmholtz theory as to the fundamental colour sensations.

(7) When the retina has been fatigued with white light, the persistences of all colour sensations are unequally increased. This apparently does not harmonise with the Young-Helmholtz theory, but indicates a partially independent white sensation.

(8) Both rest and fatigue of the retina cause an increase in the persistence of all colours. No explanation of this fact has yet been found.

(9) In the case of naturally colour-blind eyes the persistence of colour impressions to which the retina is blind is abnormally increased, thus affording a method of determining the wave-lengths to which the retina is incapable of responding normally.

(10) In addition to the loss of one fundamental colour sense, the naturally colour-blind retina may also lack the power of responding to a group of waves affecting another sensation. J. J. S.

497. *Spectra of Samarium and Gadolinium.* **E. Demarçay.** (Comptes Rendus, 131. pp. 995–998 Dec. 10, 1900.)—The author, in a previous note

ostract No. 2161 (1900)], described the lines of gadolinium between λ 5000 500. He criticises Exner's work [Reference No. 2424 (1900)], and points that great care must be exercised in the fractionation of these earths so as ensure pure spectra. S. R.

498. *Spectra of Radium and Polonium.* **G. Berndt.** (Phys. Zeitschr. 2. 180–181, Dec. 22, 1900. Communication from the Physical Institute of Halle University.)—The author first employed active barium chloride tivity 240) and active barium bromide, using a platinum spiral heated ctrically, so that very small quantities might be used, and examined the ectra for the radium lines. Of these he found only $\lambda = 3814{\cdot}591$ of ensity 2, when the intensities are reckoned from 6 to 1 so that 6 indicates greatest intensity. On using another specimen of active barium chloride tivity 1000) he obtained $\lambda = 4682{\cdot}346$, Int. 1; $\lambda = 3814{\cdot}591$, Int. 4; and a w line $\lambda = 2708{\cdot}6$, Int. 1. Up to $\lambda = 2100$ no more radium lines were ind.

The spectrum of active bismuth sub-nitrate (activity 300) was examined otographically, and the author considers the following fifteen lines to belong polonium :—

Int.	λ	Int.	λ	Int.	λ
1	4596·3	4	3342·0	3	3162·9
2	4007·7	6	3361·5	1	3152·2
4	3821·9	6	3349·2	1	2977·0
3	3467·1	4	3191·2	3	2661·9
2	3462·0	4	3168·2	4	2327·3

far as $\lambda = 2100$ no more lines were found. J. J. S.

499. *Diffusion of Ions.* **J. S. Townsend.** (Roy. Soc., Proc. 67. pp. 2–124, Oct. 26, 1900. (Abstract); Roy. Soc., Phil. Trans. 195. pp. 259–278, ec. 8, 1900.)—Investigations are described for ions produced in air at various essures by a radio-active substance and at atmospheric pressure by ultra-olet light and point discharges; also a discussion of conditions requisite to ake loss of conductivity due to diffusion during passage along metal tubing ry large in comparison with losses arising from recombination or from the utual repulsion of the ions. The rate of diffusion of the ions into a gas is at essures below the atmospheric inversely proportional to the pressure of the s. The negative ions produced when ultra-violet light falls on a zinc plate ffuse into air at nearly the same rate as the negative ions produced by a dio-active substance. The rates of diffusion of ions produced by a point scharge were found to vary considerably according to the position of the oint with reference to the metal tube, and are mostly larger than those oduced by the other methods. A. D.

REFERENCES.

500. *Comparison Spectroscope.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 20. 299–301, Oct., 1900.)—Description of a spectroscope in which it is arranged that ree spectra can be seen at the same time side by side. The instrument is designed technical use in connection with various colour industries. J. J. S.

501. *Radiographic Stereometer.* **T. Marie** and **H. Ribaut.** (Archives d'El. édicale, 8. pp. 289–299, July, 1900.)—An account of the commercial form of the strument described in Abstract No. 1424 (1900).

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502. *Emission Function.* **P. G. Nutting.** (Astrophys. Journ. 12. pp. 208–214, Oct., 1900.)—The Wien-Paschen emission formula for perfect radiators is inapplicable to represent the free emission of *imperfect* radiators in whose emission spectra there are maxima independent of the temperature at particular wave periods. The present paper is an endeavour to construct an emission function of wave-period and temperature which will hold good for the free emission of all substances at all temperatures, including line as well as continuous spectra.

After giving clear definitions of the terms employed, the author commences the discussion by treating the *intensity of emission* as a function of the temperature, and represents it by means of the inverse exponential function—

$$E = a.e.^{-b/T} \qquad (1)$$

Future experimental investigation on the variation of emission at temperatures higher than that of vaporisation may necessitate the inclusion of higher terms, but for the present these are neglected.

Again, the intensity of emission as a function of the wave period is continuous, and is single-valued in the argument for all substances, with all surface conditions, at all temperatures, and has the value zero at zero and infinity, and only at these points. For a perfect radiator it has a single maximum which varies with the temperature. If τ be the period of vibration we have for a perfect radiator—

$$E = a.\tau^{-n} e^{-\frac{\beta}{\tau}} \qquad (2)$$

Combining equations (1) and (2)—

$$E = A\tau^{-n} e^{-B/\tau T} \qquad (3)$$

which will hold for all substances having but a single maximum, and that varying with the temperature. Its maximum value,

$$E_m = A\left(\frac{n}{Be}\right)^n . T^n \qquad (4)$$

therefore corresponds to a period $\tau_{max} = \frac{B}{nT}$.

The total intensity of emission at any temperature is the integral of (3) with respect to the wave period, *i.e.*,

$$E_0 = A.B^{1-n}\Gamma(n-1)T^{n-1} \qquad (5)$$

where $\Gamma(n-1)$ denotes the ordinary gamma function.

For the case where $n = 5$, equation (3) is similar to Wien's, and (5) expresses Stefan's law.

Equation (3) cannot represent the free emission from an imperfect radiator, in whose isothermal emission curves there are maxima *not* varying in position with the temperature, *e.g.*, rock salt, when the emission is large

fined to the region near 50μ. To represent this, a sharp maximum is roduced in (3), thus—

$$E = A(\tau - \tau_m)^{-n} e^{-B/\tau T}. \quad (6)$$

E must always be real and positive, n is limited to *even, whole* numbers, so t we may write—

$$E = A\tau^{-n}(\tau - \tau_m)^{-2} e^{-B/\tau T}. \quad (7)$$

This formula should hold for any substance having only a single maximum constant period. As most substances have more than one emission ximum (*i.e.*, spectrum lines), we can generalise (7) for bodies having m h maxima by writing—

$$E = A\tau^{-n} e^{-B/\tau T} \sum_{m=1}^{m} \left(\tau - \tau_m\right)^{-2}, \quad (8)$$

ich should hold for the free emission of all substances.

The author follows the derivation of the formula by a short discussion of various limits possible, dealing with the influence of the finite *width* of the ctrum lines, the correspondence with curves obtained by other investigators, senthal, Rubens, Aschkinass, &c. C. P. B.

503. *Relations of Radiation to Temperature.* **J. Larmor.** (Nature, 63. 216–218, Dec. 17, 1900. Paper read before the British Association.)—If dulations of any kind are reflected from an advancing wall, there is more rgy in the reflected beam than there was in the incident beam, though ing to the Doppler effect its length is shorter, and therefore mechanical rk is necessary to push on the wall, and this is directly transformed into dulatory energy. The author shows, in the case of a directly incident ve-train, by applying the condition of zero displacement at the reflector, t the opposing pressure is the fraction $(c^2 - v^2)/(c^2 + v^2)$ of the intensity of total undulatory energy, direct and reflected, in front of the reflector, nd v being the velocities of propagation of the wave-train and of the vancing wall. By treating the case of oblique incidence and averaging the natural radiation in an enclosure, it is shown that the pressure is e-third of the total density (E) of radiant energy. From considering a lume V containing radiant energy travelling indifferently in all directions is proved proportional to $V^{-\frac{4}{3}}$, and, if the original state has the constitution regards wave-lengths corresponding to temperature T, it follows from rnot's principle that $T \propto V^{-\frac{1}{3}}$. Thus Stefan's law is deduced, and also ien's theoretical law, since the Doppler principle shows that in the uniform rinkage of a spherical enclosure the wave-lengths diminish as the linear mensions. The relations show that the energy of the radiation corre-onding to temperature T and lying between wave-lengths λ and $\lambda + \delta\lambda$ is of e form $\lambda^{-5} f(\lambda T)\,\delta\lambda$. The author defends the thermodynamic treatment a single ray from the objection that a beam of light is an irreversible agent. W. E. T.

504. *Radiation of Black Bodies.* **W. Wien.** (Ann. d. Physik, 3. 3. pp. 0–539, Nov., 1900.)—This paper contains a critical survey of some points in e theory of radiation. It deals first of all with Wien's Paradox, in which e of two bodies at the same temperature receives more energy by radiation om the other body than the other receives from it. [See Abstract No. 362, 01).] The author objects to parallel beams being used, as that is only a

limiting case, and he shows diagrammatically a combination of mirrors with the two Nichol prisms and the magnetic field which allows of the difference in paths of the two mutually opposite radiations being made as great as one pleases. The beams being divergent, one body receives only a small fraction of the energy which the other receives. The author points out the analogy between this problem and the one given by Clausius of two mutually radiating bodies at the same temperature but in different media. In order that they shall receive equal quantities of energy it is necessary to assume that the energy emitted by the two bodies is proportional to the square of the refractive index.

Planck has shown that the expansion or extension of radiation is a reversible process if emission, absorption, and dispersion are excluded. Wien considers that it is only reversible when the radiation, by virtue of its pressure, does the maximum possible work in expanding. He presents the following problem in support of his views: Suppose a radiating element at the centre of the diametral plane of a perfectly reflecting hemisphere of radius R_1. All the rays after reflection at the sphere return to the element. If the element is covered with a perfect reflector the radiation in the space will not be altered. If the sphere now gradually expands to radius R_2 work is done by the radiation, and this work will be sufficient to contract the sphere again to radius R_1. But suppose the sphere R_1 to be surrounded by a similar and concentric one R_2 and then R_1 to be suddenly removed or annihilated. The radiation would then extend to R_2, but would be quite different to what would have been present had the body radiated originally to R_2. A fall of temperature has been produced, and no work has been gained.

Two objections have been raised to the assumptions made by the author in deducing his formula for the partition of energy in the spectrum of a black body. The first objection is to the assumption "that the radiation is proportional to the number of radiating molecules"; it is objected to because the radiation from a body is independent of the nature of the molecules. The second objection is that in using Maxwell's law of partition a factor containing the temperature is left out. The author has dealt with the former objection in his Paris Congress address, and contends that the number of molecules is thermodynamically necessary. The second objection is here dealt with at length. If the factor is maintained the formula becomes—

$$E_\lambda = \frac{C}{\lambda^{5-\frac{3}{2}}\theta^{\frac{3}{2}}} e^{-\frac{c}{\lambda\theta}};$$

but, as he has formerly shown, all formulæ must be rejected which lead to curves steeper towards the axis than the curve

$$\frac{\text{const}}{\lambda^5},$$

i.e., the energy of any wave-length cannot diminish for an increase of temperature. The omission of the factor $(\lambda\theta)^{-\frac{3}{2}}$ is thermodynamically well supported.

The radiation, besides being proportional to the number of molecules, must be also proportional to a certain temperature function, in order that it may at all temperatures be proportional to the number of molecules.

The author considers that the discrepancies found between the law and the experimental results in the case of long waves are to be expected, as he

siders that short and long electromagnetic waves do not present only a ntitative difference in their connection with heat radiation. In absorp- n, long waves are represented by a single vector, since the continuity of tter may be assumed. In short waves the constitution of matter is of in- ence. Similar considerations must hold for emission. A theory of radiation duced for short waves cannot be expected to hold for long waves.

Paschen suggests that just as we use different formulæ for slow electric rations and for quick ones, so we ought to investigate different formulæ for ort and long waves.

Planck in his theory has deduced Wien's law from his expression for ctromagnetic entropy. His assumption of "Natural Radiation" has, wever, not yet been proved to be the only assumption which will lead to versibility. In deducing the expression for the entropy, the resonators considered as independent, while the deduction depends on several onators being present. These are the two objections to Planck's theory.

Rayleigh remarked that Wien's law would make the radiation converge wards a limit with indefinitely increasing temperature. Such is the case. the highest temperatures the increase of energy is only in the short waves. ie increase of total radiation still follows Stefan's law. J. B. H.

505. *Thermodynamics and Radiation.* **M. Planck.** (Ann. d. Physik, 3. pp. 764–766, Dec., 1900.)—The author here criticises two of the conclusions hich Wien arrives at in his paper, dealing with the theory of the radiation black bodies [see preceding Abstract.] The first point dealt with is ien's Paradox in its latest form. Planck considers that if the total radia- n into all the surrounding space (which Wien neglects) is included, the mpensation will be found which is necessary to satisfy the second law of rmodynamics.

The second point is the question of the reversibility of the free extension expansion of radiant energy. Wien in his paper gives an example of pansion of radiation in which emission, absorption, diffuse reflection, and nding are excluded, and yet which he considers is not reversible. Planck re points out that the radiation after the sudden removal of the hemisphere does not distribute itself uniformly along the radius R_2, but that at each stant there are always points on the radius at which there is no radiation one direction. At periodic intervals also the space between R_1 and R_2 is ite free from radiation, and at any one of these intervals the sphere R_1 may replaced without the expenditure of energy. J. B. H.

506. *Law of Partition of Energy.* **S. H. Burbury.** (Phil. Mag. 50. pp. 4–595, Dec., 1900.)—A discussion of the Maxwell-Rayleigh treatment of e law of equal partition of energy, and of that due to Boltzmann. The lowing conclusions are drawn:—

1. The law of equal partition of energy among the translation velocities is t proved by the Maxwell-Rayleigh method.

2. It is not proved by Boltzmann's method, because the fundamental sumption on which that method is based is not proved.

3. Subject to any proof that may be given hereafter of Boltzmann's sumption, the law is not generally true in any sense whatever. When, wever, the density is very small, the different energies in question will fer from each other only by small quantities of the second order. The law ay therefore be asserted for the limiting case of an infinitely rare gas. [See o Abstract No. 991 (1900).] E. H. B.

507. *Distribution of Energy in the Normal Spectrum.* **M: Planck.** (Deutsch. Phys. Gesell., Verh. 2. 17. pp. 237–245, 1900.)—The author describes a new method of determining, by means of two constants of nature, the distribution of a given amount of energy in the normal spectrum, and the corresponding temperature. He considers a large number of simple vibrators (N with frequency ν, N′ with frequency ν', &c.) in a medium, enclosed by reflecting walls, and in which the propagation of light is c; he assumes E_0 of the total energy (E_ϵ) to be in the vibrators, and E to be in the N vibrators, E′ in the N′, &c. He also assumes E to be composed of a finite number (P) of equal elements of energy (ϵ), putting $\epsilon = h\nu$, where h is a constant, and $E = P\epsilon$, and calls any distribution of these P elements amongst the N vibrators a "Complexion." The number of possible complexions would be $\frac{(N+P-1)!}{(N-1)!\,P!}$, or approximately $(N+P)^{N+P}/N^N P^P$.

The product (R) of the corresponding numbers for all the sets of vibrators is the number of possible complexions corresponding to the assumed distribution of energy. Of all assumed distributions one gives a maximum value (R_0) for R, and the vibrators would take up this distribution in a stationary field of radiation if the E_0 were the energy divisible amongst them. The quotients of E by N, &c., give the stationary values U_ν, &c., of the energies of the individual vibrators of each kind; the equation $u_\nu d\nu = \frac{8\pi\nu^2}{c^3} U_\nu d\nu$ then gives the space density of the vibratory energy in the medium, and thence the energy in the medium is obtainable, and the assumed value of E_0 may be tested and corrected. The corresponding temperature is obtained from the equation—

$$\frac{1}{\theta} = k \frac{d \log R_0}{d E_0}$$

This distribution is represented by the expression—

$$u_\nu d\nu = \frac{8\pi h\nu^3}{c^3} \cdot \frac{d\nu}{e^{\frac{h\nu}{k\theta}} - 1}$$

which corresponds to the formula previously given by the author, viz. :—

$$E_\lambda d\lambda = \frac{c_1 \lambda^{-5}}{e^{\frac{c_2}{\lambda\theta}} - 1} d\lambda$$

The values of the constants, $h = 6.55 \cdot 10^{-27}$, $k = 1.346 \cdot 10^{-16}$, were determined from this formula by means of the measurements of Kurlbaum, and Lummer, and Pringsheim. The proof of the validity of the method is based upon the propositions that the entropy of the system in any state is proportional to the logarithm of the probability of this state, and that the probability of every state is proportional to the number of complexions corresponding to it, all complexions being of equal probability.

From a comparison of his own reasoning with that of Boltzmann on gas molecules, the author deduces from k an estimate (6.175×10^{23}) for the number of molecules in the gramme molecule of any element, which agrees with the value determined by Meyer. The values also derived for the mean *vis viva* of an atom at absolute temp. 1°, and for the electric charge on an electron are in fair agreement with previous determinations. W. E. T.

508. *Correction of Wien's Equation.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 2. 13. pp. 202–204, 1900.)—The author shows that possibly the functional equation from which he had previously deduced Wien's equation [Abstract No. 1446 (1900)] was not sufficient to determine the quantities involved. He therefore assumes, as an arbitrary expression for the entropy, the expression next in order of simplicity to the one which had led to Wien's equation. From this he deduces the energy equation—

$$E = \frac{C\lambda^{-5}}{e^{\frac{c}{\lambda T}} - 1}.$$

As a consequence of the electromagnetic theory, and states that it appears to agree with observation, at least as well as the equations of Thiesen, Lummer and Jahnke, or Lummer and Pringsheim. W. E. T.

509. *Theory of the Transition-layer between Liquid and Vapour.* **G. Bakker.** (Zeitschr. Phys. Chem. 35. pp. 598–603, Dec. 7, 1900.)—The author regards it as always possible to substitute for a molecularly constituted medium a continuous medium, so that the attractive forces supposed to act between the volume-elements of the latter will agree with the mean values of the attractive forces acting between the volume-elements of the former medium. It is necessary, however, to distinguish clearly between the law of force between *two molecules* and that between two *volume-elements*. The following theorem is proved :—

"Substituting for the liquid, transition-layer, and vapour, a continuous medium whose density equals that of the body at every point, and whose volume element are subject to attractive forces derived from a potential $-f\frac{e^{-qr}}{r}$, then $3A - 2B = H$, when A = the work required to separate the elements of the medium, B = the virial of the attractive forces, and H = Laplace's constant." F. G. D.

510. *Rankine's Formula for Vapour-pressure.* **P. Juliusburger.** (Ann. d. Physik, 3. 4. pp. 618–659, Dec., 1900.)—The different deductions of Rankine's law,

$$\log f = A - Bt^{-1} - C \log t,$$

for the relation between the absolute temperature t and the saturation-pressure f of a vapour f are examined, and are shown to be of the same value, being all founded on the same assumptions. The law is theoretically valid only for very low pressures ; but examination of the observations on 110 vapours shows that, with empirical values are given to the constants, it is of practical use in a much wider range and for some substances may be pushed right up to the critical point. The formula is applicable, too, to a wider range of dissociation-phenomena than has hitherto been suggested. R. E. B.

511. *Illustrations of the Statistical Dynamics of Gas Theory.* **J. Larmor.** (Nature, 63. pp. 168–169, Dec. 13, 1900. Paper read before the British Association.)—It is shown that in a swarm of meteors moving in a conservative field of force there is a quantity which is conserved in each group, viz., the ratio of the density at a group (estimated by numbers and not by size) to the extent of the region on the velocity-diagram which corresponds to it (estimated by divergence from the velocity of the central meteor of the group) ; but this quantity may vary from group to group. This result carries the general law

that the concentration in cross-section of a beam of light at different points of its path is proportional to the solid angular divergence of the rays multiplied by the square of the refractive index. Interaction of two streams will cause disturbance, and for the velocities to remain statistically unchanged the particles in each group must range uniformly with respect to distribution in position and velocity jointly; as, however, in this case each value of the resultant velocity would occur with a frequency proportional to its square, a factor such as $exp(-hE)$ is required to keep down very high values, where E is the total energy of a particle and h a constant which defines the temperature. R. E. B.

512. *Gibbs' Thermodynamical Model with van der Waals' Characteristic.* **W. P. Boynton.** (Phys. Rev. 11. pp. 291–303, Nov.–Dec., 1900.)—This characteristic, in its reduced form,

$$(\pi + 3\nu^{-2})(3\nu - 1) = 8\vartheta,$$

where $\pi \equiv p/p_c$, $\nu \equiv v/v_c$, $\vartheta \equiv T/T_c$, the subscripts denoting critical values, leads to the relations

$$\begin{aligned} \psi \equiv (\phi - \phi_c)/C_v &= \log \vartheta + 8\alpha \log \tfrac{1}{3}(3\nu - 1) \\ &= \log \tfrac{1}{4}(\pi + 3\nu^{-2}) + (1 + 8\alpha)\log \tfrac{1}{2}(3\nu - 1), \end{aligned}$$

where $\alpha \equiv R/8C_v$, on the assumption of the constancy of the isometric specific heat C_v, and to the relation

$$\zeta \equiv E/E_c = \{\vartheta + 9\alpha(3 - \nu^{-1})\}/(1 + 18\alpha),$$

on the further (unstated) assumption that $E = 9p_c v_c$ when $T = 0$ and $v = \infty$. Thus by eliminating ϑ and writing $x \equiv \nu$ we obtain for the reduced characteristic surface—

$$(1 + 18\alpha)\zeta = e^{\psi}\{(3x - 1)/2\}^{-8\alpha} + 9\alpha(3 - x^{-1}).$$

With the value $\alpha = 1/28$ (*i.e.*, $R/C_v = 2/7$), as suggested by the kinetic theory for triatomic gases such as CO_2, the projections on the xz plane for the isentropics given by $\psi = -4, -3, -2, -1, 0, 1, 2$ are plotted, and also the projections on the xy plane of the isothermals for $\vartheta = 0{\cdot}25, 0{\cdot}5, 0{\cdot}75, 1, 1{\cdot}25, 1{\cdot}5, 1{\cdot}75, 2$ and of the isopiestics for $\pi = -1, 0, 0{\cdot}5, 1, 2, 3$.

Instability being characterised by $\partial p/\partial v > 0$, *i.e.*, if $\nu > \frac{1}{3}$ by —

$$4\vartheta < \nu^{-3}(3\nu - 1)^2$$

or—

$$\pi < \nu^{-3}(3\nu - 2)$$

or—

$$e^{\psi} < x^{-3}\{(3x - 1)/2\}^{2+8\alpha}$$

or—

$$(1 + 18\alpha)\zeta < \tfrac{1}{4}x^{-3}(3x - 1)^2 + 9\alpha(3 - x^{-1}),$$

the projections on the coordinate planes of the curve bounding the region of instability are obtained by substituting $=$ for $<$ in the above, and these are plotted.

Comparison of these results with Maxwell's diagram discloses discrepancies which, the author states, do not disappear on taking the diagram to be drawn in perspective [as should obviously be done]. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

513. *Diurnal Variation of Atmospheric Electricity.* **A. B. Chauveau.** mptes Rendus, 131. pp. 1264–1266, Dec. 24, and 1298–1300, Dec. 31, 1900.)—nclusions are drawn from the results of an uninterrupted series of half-urly observations made at the Bureau Central Météorologique and at the of the Eiffel Tower during the years 1893–99. The mean values of the reau Central observations have been calculated for the seasons, summer, um.n, and w nter, but of the Eiffel Tower readings, for summer and autumn y. It is found that while the mean diurnal potential at the Bureau Central nges from 134 volts in summer to 177 in autumn, the potential on the fel Tower remains nearly constant. Hence the equipotential surfaces near earth come closer together during the autumn while those at a relatively all distance above it experience no such change. Thus the vertical varia-n of the field is modified by the seasons; but this modification, though ge near the ground, is inappreciable at 30 metres. The variations due he passage of the negative electricity of the earth into the atmosphere are refore limited to a very shallow layer of air close to the ground.

Having subjected the results of his observations to harmonic analysis author (in the second paper) concludes that if the diurnal variation be resented by the sum of five terms of a Fourier series the first two terms l give what may be termed the principal wave and the remainder the ondary one; the latter is of less importance in winter than in summer and so great on the Eiffel Tower as on the ground. These analytical results nfirm the law above stated. [See further Abstracts Nos. 1060 and 1061 00).] J. E.-M.

DISCHARGE AND OSCILLATIONS.

514. *Sparking Distances between Plates for Small Distances.* **R. F. rhart.** (Phil. Mag. 1. pp. 147–159, Jan., 1901.)—The author's experiments re made with exceedingly short sparking distances, so that a very delicate thod of measuring the thickness of the separating medium was required. e of the spark terminals was a metal sphere rigidly attached to a fixed port; the other terminal was a disc mounted on a movable carriage which rs one of the mirrors of an interferometer. The distance of separation ween the plates is measured by counting the fringes which move across field of view as the terminals are drawn apart, the passage of one fringe oss the field corresponding to the movement of the carriage through a dis-ce of half a wave-length. The only dielectrics used were air and carbon xide gas. The results are plotted as curves. In the case of air at atmo-eric pressure the curve takes a sudden bend when the distance is between ee and four wave-lengths, and the author considers this another argument in our of the hypothesis of an air-film surrounding the surfaces of the bodies, thickness of such film being thereby indicated as $1{\cdot}5\lambda$ (sodium light). e curves showing the effect of pressure with air, and the carbon dioxide ves are also discussed in the light of this hypothesis. W. C. H.

515. *Carbon Filaments and Lightning Flashes.* (Correspondence in Electrician, 45. pp. 828 and 829, Sept. 21 ; and p. 868, Sept. 28, 1900, by the **Editor**, **W. Langdon, S. P. Blackmore,** and **W. S. Andrews.**)—A curious phenomenon has occasionally been observed in the glow-lamps on the circuits of the Calcutta Electric Supply Company at times when Calcutta has been visited by exceptionally severe thunderstorms. Immediately following each lightning flash the brightness of the glowing lamps has been observed to increase suddenly, gradually returning to its normal value. The editor suggests as a possible explanation that the carbon of the filaments may undergo some kind of "coherer" action, their resistance being temporarily reduced by the electric waves, and then gradually restored through self-decoherence. The correspondents quote various cases of lamps and even dynamo armatures being burnt out, especially in the Transvaal and the Western States of America. E. E. F.

516. *Propagation of Electric Oscillations along a number of Parallel Wires.* **W. B. Morton.** (Phil. Mag. 50. pp. 605–616, Dec., 1900. Abstract of a paper read before the British Association.)—When simple harmonic electromagnetic waves are guided along conducting wires of finite resistance, the effect of the leads is to produce, first, a retardation of the speed of propagation as compared with that in free space, and, second, an attenuation of the amplitude of the waves as they proceed. The determination of these two effects is what is mainly wanted in the solution of the problem. The cases of a single wire in a sheath and a single wire isolated have already been given by J. J. Thomson, and by Sommerfeld respectively. The case for two parallel wires has been treated by Heaviside, and recently very fully by G. Mie. The latter [see Abstract No. 2027 (1900)] obtains a single formula from which the solution can be found to any desired degree of accuracy. The object of the present paper is to show how the *first approximation* to the complete solution may be very simply deduced from the known single-wire solution. This approximation consists in the neglect of the *square* of the small quantity, radius of wire divided by distance apart. A number of cases are now worked in detail on this plan, the chief results being as follows :—

(1) *Two nearly equal Wires.* When two wires are used of which one is, say, 1 per cent. thicker than the other, one being the return wire to the other, then the *larger* wire carries *less* current and surface charge than its fellow. If, however, both wires are similarly charged instead of one being the return, then the larger wire carries the larger current.

(2) *Three Wires in Isosceles Triangle.* If the base wires are the same size and carry equal and opposite currents, the vertex wire is quite free from current. Hence, when two wires are conveying electric oscillations, a third wire equidistant from them plays a passive part. Thus, if there are two pairs of wires at the corners of a *rhombus*, there will be no mutual influence between the pairs. For example, telephone messages sent along the pair at the ends of one diagonal of the rhombus will not be overheard along the other pair.

(3) *Four Wires in Rectangular Arrangement.* When two wires serve as the returns for the other two, the speed and attenuation are the same as if we had *two* wires at distance equal to the product of the two distances of opposite wires divided by the distance of the similar wires ; where *opposite* refers to a wire and its return, and *similar* to wires carrying similar currents and charges.

(4) *2n Wires at corners of Regular Polygon, consecutive wires being opposite.* Let r be the radius of the circumscribing circle, then the speed and

nenuation with this arrangement are the same as for a pair of leads at stance $2r/n$.

(5) *n Wires at corners of Regular Polygon, all carrying similar Currents.* In s case, when the skin-effect is marked, the n wires produce the same effect the waves as a single wire of n times the perimeter; but when the currents not concentrated on the surface, but occupy the whole section, the wires can be replaced by a single wire of n times the *area*. E. H. B.

517. *Luminescence of a Rarefied Gas surrounding Metallic Wires attached to of the poles of an Induction Coil.* **J. Borgman.** (Comptes Rendus, 131. 1196–1198, Dec. 24, 1900.)—Continuing his earlier experiments [see stract No. 1670 (1900)], the author now describes some further observations the luminescence produced in a glass tube containing a rarefied gas and ing a platinum wire along its axis, when one end of this wire is attached ough a condenser to one of the poles of a Ruhmkorff coil whose other pole o earth, the poles being branched by a spark-gap. The different luminous ects produced according to the dimensions of the tube, the pressure of the , and the length of the spark-gap, and according as the positive or negative e of the coil is attached to the wire, are all described. Still further iations are produced by pasting a strip of tin-foil, connected to earth, on outside of the tube; and again by using a tube in which there are two es parallel to the axis and insulated from one another. W. C. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

518. *Electrocapillary Phenomena.* **Gouy.** (Comptes Rendus, 131. pp. 939–, Dec. 3, 1900.)—Helmholtz's theory of the double layer, with the recent dition that the electric layer of the electrolyte is formed of ions, is ufficient. It does not take non-electric forces ("capillary affinity") into ount. The electrolyte must be assumed homogeneous; but it can be wn that in the liquid mass the concentration varies with the area of the rcuro-electrolytic surface: and this implies a strengthening or a weakening the solution in the neighbourhood of this surface; strengthening where maximum varies in a sense opposed to the concentration, and weakening the case of so-called active substances. At the maximum, where the rcurial layer is *nil*, the non-electric forces accumulate the anions on the face of the electrolyte and produce a negative layer, the amount of which ies with the degree of concentration. Behind these there is an equal layer kathions, held there by electric forces. Where the mercurial layer is itive, there are more anions and more kathions. When it is negative, the ctric forces tend to disperse the anions in opposition to the non-electric es, and may result in the superficial layer being composed of kathions, and he constitution of the double layer of the ordinary theory. We, have then, do with three layers (one mercurial and two electrolytic), which may be uced to two layers. In the theory of capillarity the attractive forces ween the mercury and the electrolyte reduce the surface tension; so do electric forces: and the effect is greater the greater the concentration the more "active" the anions. At the maximum the mercury is negative he electrolyte: and the difference of potential between the mercury and electrolyte is due to the electrostatic action of the different layers cribed. Let the area of the mercury suddenly increase: electric ilibrium is rapidly restored, all kinds of anions being attracted to form perficial layer: but gradually the less active anions are replaced by more ve ones, and the superficial tension gradually falls. A. D.

519. *Permanent Changes in Metallic Wires, and Variation of their Electrical Resistance.* **H. Chevallier.** (Comptes Rendus, 131. pp. 1192–1194, Dec. 24, 1900.)—The author has already published the results of experiments to determine what permanent changes are produced in a wire of platinum-silver alloy under the influence of temperature, and especially the change produced in its electrical resistance [see Abstracts Nos. 862 and 1857 (1900)]. The object of the present investigation is to determine whether maintaining a steady temperature T in the wire for a certain time, or keeping the wire for the same time at a temperature oscillating constantly between T and $T - \varepsilon$, is more effective in producing this permanent change of resistance. The same wire is exposed to a series of heatings, all of the same duration but alternately steady and oscillating, and the resistance is measured during each heating. The temperatures chosen for the experiments are: (1) $T = 320°$, $T - \varepsilon = 305°$; (2) $T = 490°$, $T - \varepsilon = 470°$. These temperatures are chosen because 320° and 480° correspond respectively to a point of maximum and of minimum in the curve of "limit of limits," explained in the earlier paper [Abstract 1857 (1900)], and a cause of error is thereby eliminated, since at these temperatures the "limit of limits" is independent of the temperature through a range of 30° to 40°. The experiments show that the oscillating temperatures produce a greater change in the resistance than the steady temperatures, and the author concludes that the permanent modifications in the body itself are mostly due to such small oscillations of temperature. W. C. H.

520. *Measurement of Small Electromotive Forces.* **E. Bose.** (Phys. Zeitschr. 2. p. 152, Dec. 8, 1900.)—By means of a millivoltmeter having a resistance of 1 ohm and 150 scale divisions, when arranged as in Fig. 1, potential differences as far as 0·150 volt can be read through compensation.

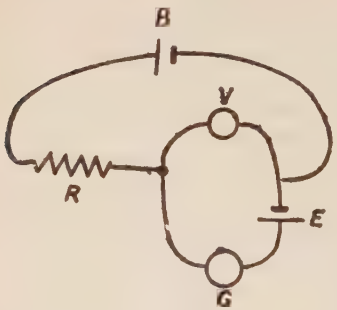

FIG. 1.

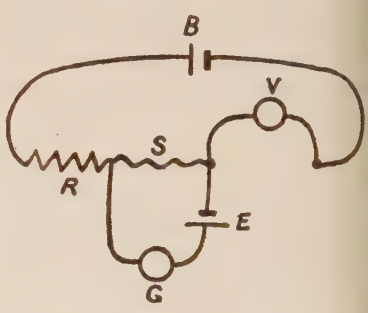

FIG. 2.

In the Figures, E is the e.m.f. to be measured, B the compensating e.m.f., R an adjustable resistance, V the voltmeter, and G a null-instrument. Such a voltmeter permits of the accurate measurement of very much smaller potential differences by making use of subsidiary resistances of $\frac{1}{9}$, $\frac{1}{9^2}$, $\frac{1}{9^3}$, $\frac{1}{9^4}$, $\frac{1}{9^5}$, and so on, connected to the instrument for current measurement. Such a subsidiary resistance is connected in front of the millivoltmeter, and compensation is made at its ends. Then 9 times, 99 times . . . the value of the compensated e.m.f. is read off on the instrument. The arrangement is sketched in Fig. 2, in which S is the subsidiary resistance. It permits of the measurement of small e.m.f.'s without interpolation, and without a normal element with the help of any resistance-box since the value of this does not come into the measurement. J. J. S.

521. *Ballistic Galvanometer Errors.* **R. Beattie.** (Phil. Mag. 50. pp. 575–I, Dec., 1900.)—When using a ballistic galvanometer of the movable gnet type, unless very great care is taken to have the magnetic axis of the dle exactly in the plane of the coil a source of error is introduced, magnitude of which is here investigated. The error arises from the gnetic field, caused by the current in the galvanometer coils, having a nponent along the axis of the needle tending temporarily to alter its mag-ic moment. The throw of the needle is not then proportional to Q, the ntity of electricity which traverses the galvanometer, but to—

$$Q + \alpha G\theta \int_0^\tau i^2 dt,$$

ere G is the coil constant of the galvanometer, α the induction coefficient the needle, θ its (small) initial angular displacement, i the instantaneous ue of the current, and τ its duration. The value of α is about 0·002. In discharging a condenser through the galvanometer—

$$\int_0^\tau i^2 dt = \frac{EQ}{2R},$$

l the percentage error becomes

$$50\alpha \cdot \frac{G}{R} \cdot \theta E.$$

a sensitive galvanometer $\frac{G}{R}$ will not differ greatly from unity, so that the or per degree would be only 1 per cent. for $E = 600$ volts.

The errors are experimentally determined in one particular case, where a ndenser is connected in series with a galvanometer across the two poles of witch which closes a battery circuit of considerable self-induction. On ening the switch the current is broken and the condenser becomes charged ough the galvanometer, the energy in the circuit being thereby absorbed. e percentage error in this case is given by—

$$\frac{50\alpha G\theta}{QR}(LI^2 + EQ).$$

The experiments were arranged so that the second term was small com-red with the first, and the values of θ varied from $+6°$ to $-4°$.

The percentage excess of abnormal over normal throw $= 330\theta I^2$, which es the induction coefficient of the needle as 0·0015. J. B. H.

522. *Electrical Measuring Instruments at the Paris Exhibition.* **M. Aliamet.** c. Int. Élect., Bull. 17. pp. 265–325, July–Aug., and 329–402, Sept.–Oct., 0.)—*Galvanometers.*—The Broca astatic galvanometer has a moving system sisting of two vertical needles, each with a consequent pole at its centre d poles arranged thus : $\begin{matrix} N & S \\ S & N \\ N & S \end{matrix}$; in this way the system is astatic, although the o needles may have different strengths of magnetisation. One pair of bbins is fixed with its axis at the height of the consequent poles, the end les being outside the bobbins. This galvanometer is made by J. Car-ntier, who also exhibited a ballistic d'Arsonval galvanometer fixed on a ius suspension. The moving coil, of 500 ohms resistance, is very long a horizontal direction so as to increase the moment of inertia ; the period

is 8 seconds, and 1 microcoulomb gives a throw of 40 mm. on a scale at a distance of 1 m. The Julius suspension consists of three metallic wires fixed to the ceiling and attached to the galvanometer at three clamps in a plane containing its centre of gravity. To avoid swinging, vanes dipping in oil are attached to the bottom of the galvanometer. Ducretet showed a registering d'Arsonval galvanometer with six circular magnets fixed horizontally; the moving coil carries a flexible arm terminating in a pen, which is pressed against the registering drum at intervals by means of an electromagnet. Hartmann and Braun exhibited several types of galvanometer, among which a portable mirror galvanometer is worthy of mention. This carries on one tripod a scale and telescope supported on an arm which is jointed in the middle of its length, so as to bring the telescope and scale close to the body of the galvanometer when it is required in a portable form; a clamp is provided to fix the moving system. Callendar's registering galvanometer, made by the Cambridge Scientific Instrument Company, is arranged to register resistance measured on a Wheatstone bridge, or potential on a potentiometer. A deflection on the galvanometer closes one of two relay circuits and releases a clockwork mechanism, which moves a carriage along the slide wire of the bridge in one direction or the other until balance is obtained. The carriage also carries the registering pen. To ensure the galvanometer making contact with very slight pressure, two contacts, carried by an arm attached to the moving coil, are arranged one on each side of an insulating disc, covered on each face with platinum. This disc is revolved continuously by clockwork and its surfaces are kept clean by rubbers.

Galvanometer Accessories.—Hartmann & Braun exhibited two supports for scale, telescope, and lamp. One consists of a tube fixed vertically to the wall which carries an arm capable of up-and-down motion, and balanced by a counter-weight in the tube. The end of the arm carries the telescope, scale and lamp, with various rack and worm-wheel adjustments. The second support is in the form of an inverted pyramid, arranged to run along a beam fixed to the ceiling; the telescope is fixed to the lower end, and carries the scale fixed to its body. In Siemens and Halske's arrangement the lamp and scale are immediately below the galvanometer, and the incident and reflected lights are reflected at right angles by a total reflection prism placed near the galvanometer mirror.

Ammeters and Voltmeters.—A large number of these instruments of the d'Arsonval type are exhibited, but present no novel features. The Carpentier alternate-current ammeter, made by the Société Industrielle des Téléphones, consists of a pair of horseshoe electromagnets acting on a flat, oblong coil which is pivoted at one end. The magnet poles embrace the edges of the coil, which is connected in series with the magnets. The current causes the coil to move in its own plane from one magnet towards the other. The coil is connected through a pair of levers with the needle, and is damped by a pair of air dash-pots. The current is introduced through a transformer, with a single turn in the primary, and a high-resistance secondary. The voltmeter is exactly similar, except that the magnets are wound with German silver to diminish the effect of their self-induction. The indications vary slightly with the frequency, but this variation may be compensated by inserting a transformer with a high-resistance primary coil. Siemens and Halske showed a rotary field ammeter, constructed on the lines of a four-pole induction motor, with an aluminium drum as rotor. The current passes through one pair of field-coils, while the other pair are short-circuited on themselves. The control is a spiral spring, and oscillations are damped

permanent magnets embracing an auxiliary aluminium disc. Horn con-
acts an electromagnetic voltmeter with two scales, one in black for
ntinuous currents, the other in red for alternate currents. Two short
inders of sheet-iron are supported eccentrically in a solenoid, one on
h side of the axis and at each end of the solenoid. Their motion, under
influence of the field in the solenoid, tends to place them coaxial with
solenoid, and it is transmitted to the needle by a jointed frame, which
ves also as their support. A novel exhibit is Arno's electrostatic voltmeter,
ed on the principle that a dielectric in a rotary electrostatic field tends to
ate with the field by reason of the lag in its polarisation. Three segments
metal cylinder, which are connected to a three-phase supply, surround a
affined paper cylinder; the rotation of the latter is controlled by a spiral
ing. The scale has exactly equal divisions.

Resistances.—The instruments in this section were all of well-known types,
l call for no special mention. Chauvin and Arnoux employ constantan in
construction of their resistances, and, to avoid the effect of the high
rmoelectric power which this alloy possesses, the terminals, slides, and
fittings of their resistance-boxes are also of constantan. The Physical-
hnical Institute of Charlottenburg showed high resistances made by
ndt's process: a mixture is made of gold and platinum chloride in
nomile oil, and a spiral line is painted on a porcelain tube by a brush
ped in the mixture; this spiral is reduced to the metallic state by burning
muffle, and then possesses a very high resistance.

Potentiometers.—Chauvin and Arnoux showed a portable potentiometer
h slide wire, similar in arrangement to Crompton's potentiometer. The
e-wire contact is adjustable relatively to its index, so as to compensate for
temperature variation of the standard cell. A scale is provided marked
degrees Centigrade.

Ohmmeters.—Direct-reading instruments having one fixed and one moving
were shown by Carpentier, Hartmann and Braun, and Siemens and
ske. The first maker also showed an ohmmeter with two fixed coils,
ng on a soft iron needle; the pointer attached to this is prevented from
llating by a fork which allows it only a limited motion; the fork is
ed by a milled head to the position of equilibrium of the needle.

Earth Detectors.—Siemens and Halske exhibited an electrostatic voltmeter
pted to the purpose of indicating the insulation of live conductors; the
conductors of a line are connected to the two pairs of quadrants, the
r needle is connected to earth. If the insulation of one conductor
inishes the needle deflects towards the quadrants to which the other
ductor is connected; there is, however, no deflection in the case of
conductors equally diminishing in insulation. Arno has devised
lar instruments for three-phase circuits, based on the principle of his
trostatic voltmeter.

Condenser Standards.—Carpentier makes standard condensers formed of
ts of mica silvered by chemical deposition. Keiser-Schmidt showed
ndenser having a very small residual charge with a dielectric formed of
nically pure paper impregnated with an insulating material, the nature
hich is kept secret.

Wattmeters.—With the exception of the induction wattmeters made by
Allgemeine Elektrizitäts-Gesellschaft, all those exhibited were of the
tro-dynamometer type, either with torsion head or direct-reading.
ens and Halske make non-inductive resistances for connecting in
s with the pressure coil of their wattmeters by winding flat wires

on thin sheets of mica, the requisite number of sheets being fixed side by side in a box about 7 mm. apart.

Phasemeters.—In the Siemens' type two coils, carrying the two currents, are placed perpendicularly, and produce a rotary field whose amplitude varies with the difference of phase between the two currents. Its amplitude is measured by the rotation of a metallic disc, embraced by the coils, and controlled by a spring. Arno's phasemeter consists of an electro-dynamometer with torsion head, the two coils carrying the two currents. Inside these coils is suspended a pair of coils fixed perpendicularly to each other and short-circuited on themselves. This system is also provided with a torsion head. From the readings of the two torsion heads may be calculated the tangent of the angle of phase-difference.

Curve-tracers for Alternate Currents.—Abraham's rheograph differs essentially from Duddell's in having a galvanometer coil of very long period. In order that the force acting on the coil may be at all times proportional to the current this is transformed as follows : The transformer consists of two pairs of flat coils, one pair within the other, and relatively adjustable in respect to their planes. The current undergoes double transformation, the secondary of the first pair of coils being in series with the primary of the second. The fourth coil is in series with the galvanometer coil and with an adjustable resistance in the main circuit of the first coil, and also receives an induced e.m.f. impressed by the first coil, and adjusted by varying the relative inclinations of the planes of the coils. These adjustments are made till the galvanometer correctly registers the curve of an interrupted continuous current. An interrupter for this purpose is fixed on the shaft of the synchronous motor provided with the instrument. Stieberitz, of Dresden, showed a curve-tracer with a galvanometer having a period of only 0·0001 second. For a current of 100 $\sim$ the apparatus traces one complete curve in two seconds. Ganz & Co. showed a Joubert contact-maker designed by Hoor, which can be held in the hand and pressed against the alternator shaft like a speed-counter.

Permeameters.—Carpentier's permeameter consists of a massive iron ring with two air-gaps diametrically opposite. In one is suspended a magnetised needle with torsion head and scale. The test-rod, surrounded by a magnetising coil, is fixed across the ring on a diameter perpendicular to that on which are the air-gaps ; the induction in the test-rod is then proportional to the torsion required to bring the needle to zero. The effects of hysteresis are eliminated by a double reading as follows : After the needle has been brought to zero by turning the torsion index the scale is turned round so as to bring the zero under the index ; the current is then reversed and the torsion head turned to bring the needle to zero. Its reading then gives directly the value of the induction. An ammeter is provided reading directly in maxwells. Hartmann and Braun make a complete apparatus for measuring permeability by means of a bismuth spiral ; it contains an iron yoke to take the test-pieces, an ammeter, and a slide-wire resistance bridge to measure the variations in resistance of the bismuth spiral. Siemens and Halske's permeameter, designed by Kath, consists of a d'Arsonval galvanometer, an iron yoke with magnetising coil replacing the usual permanent magnet. The test-rod completes the magnetic circuit of the yoke and carries the coil. A constant current is passed through the moving coil, the index of which moves over an arbitrary scale, calibrated in gausses. Two small coils, in series with the magnetising coil, but wound in the opposite direction, compensate for the field due to the yoke itself. G. H. B.

523. *An Electric Micrometer.* **P. E. Shaw.** (Phil. Mag. 50. pp. 537–562, ec., 1900. Paper read before the Physical Society of London, March 23, 00.)—The amplitude of vibration of a telephone diaphragm is here experi-lentally measured by a micrometric arrangement. A fine micrometer screw oves the first of a system of three levers arranged so that the motion of the e end of the third lever is about one-thousandth part of the motion of the icrometer screw. A platinum point fixed to this free end makes contact on platinum-iridium disc on the telephone diaphragm. This contact closes a rcuit through a cell and a telephone receiver which the observer holds to his r, and he thus knows immediately a contact is made. Currents of different rengths are sent through the coils of the telephone under examination, and e corresponding motion of the diaphragm is measured. By this means a rve is plotted, giving the connection between current-strength and motion the diaphragm. To determine the motion corresponding to the limits of dibility, the current is measured which when made and broken in the tele-one receiver just produces an audible sound when the receiver is held to e ear. By extrapolation from the above curve the corresponding motion of e diaphragm is obtained.

The connection between the diaphragm motion and the sound produced given as follows :—

1. Begins to be audible	0·4	$\mu\mu$
2. „ „ comfortably loud	50	„
3. „ „ uncomfortably loud	1000	„
4. „ „ overpowering	5000	„

The author considers that the method of electric contact here adopted has oved reliable, and that the lower limit of the lengths which can be measured this means is much lower than that attained by the optical methods epending on some wave-length. The difficulties arising from vibration of e building and from temperature differences were successfully overcome.

J. B. H.

524. *Tests of Electric Supply Meters at the Reichsanstalt.* **K. Feussner.** Elektrotechn. Zeitschr. 21. pp. 1035–1038, Dec. 13, 1900. Communicated by e Physikalisch-Technischen Reichsanstalt.)—Current and pressure are btained from accumulators, which can be connected in various ways in series parallel by mercury switches. The maximum current that can be taken is 0,000 amperes. The main resistance consists of 800 strips of "constantan,' hich can be switched into parallel one after the other. For currents higher an 6,000 amperes, a water-cooled tubular resistance of about 0·002 ohm is ined in parallel with the strips. Portable slide-wire rheostats are used for act adjustment with moderate currents. Measurements of current and essure are mostly made with instruments of the Weston type. Times are ken either by a stop-watch or by a recording chronograph : the latter mits of at least twice the accuracy of the former, and hence saves time in sting. No meter has hitherto been found sufficiently accurate to serve as a andard. In the case of meters for large currents, the current in the leads as often a perceptible effect on the readings, and the tests are therefore rried out with the leads in the position which they will have when the eter is in use, this position being specified on the certificate of the test. It as been found advisable to measure the resistances of the meter first of all. he rate of the meter is taken by short tests, at $\frac{1}{5}$, $\frac{1}{2}$, and full load, and it is en run at full load for an hour.

W. H. E.

525. *Testing Alternate-Current Supply Meters.* **E. Orlich.** (Elektrotechn. Zeitschr. 22. pp. 94–98, Jan. 31, 1901. Communicated by the Physikalisch-Technische Reichsanstalt.)—A detailed description of the arrangements adopted by the Reichsanstalt for calibrating single-phase and polyphase supply meters of various types. The pressure-coil of the meter having been connected for half an hour to a source of e.m.f. corresponding to the specified p.d., the constant of the meter is determined for the following conditions of use :—

Current	0·2 of full-load	0·6 of full-load	Full-load	Full-load	Full-load
Power-factor	1	1	1	0·6	0·2
				or 0·5	

The readings having been taken, the meter is kept working at full load for one hour, and then the above series of readings is repeated in the reverse order. If the time required to make the measurements be included, then on the whole the meter is kept working at full load for about two or three hours. In making a measurement, the wattmeter readings (there are always 2 wattmeters in circuit) are taken first, then the time measurement, and finally the wattmeter readings again. The currents for the meter are supplied by two transformers connected to a three-phase generator driven by a continuous-current motor which receives current from a set of large storage cells. The phase-shifting device consists of an induction motor whose rotor may be fixed in any desired position relatively to the stator. A. H.

526. *Fault-Finding on Cable Drums.* **R. Appleyard.** (Phys. Soc., Proc. 17. pp. 104–107, July, 1900.)—The rubber-covered cable is wound off drum B, on to drum A, while the galvanometer G is connected to the core as if insulation were being taken by direct deflection. W is a wire spiral and C is a wet

cloth outside the cable. If there is a single fault only, the deflection of G falls when the fault passes under the guard wire. If there are several faults the deflection falls for each one. If r is the ordinary dielectric resistance of the total length of core when there is no fault ; m and n ohms are the surface resistances between the guard wire W and A and B respectively ; f the resistance of the fault ; b the battery resistance ; g the galvanometer resistance ; E the e.m.f. of the battery, then the current G in the galvanometer is given by—

$$G = \frac{E}{(r+g+b)+\left\{\frac{g}{m}(r+b)+\frac{b}{n}(r+g)+\frac{brg}{mn}\right\}}$$

M. O'G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

§ 527. *Chemical Formulæ and the Invariant Theory.* **P. Gordan** and **W. Plexejeff.** (Zeitschr. Phys. Chem. 35. pp. 610–633, Dec. 7, 1900. From the Report of the Meeting of the Physico-Medical Society at Erlangen.)—The authors have investigated more closely the analogy between the algebraical theory of invariants and covariants and the atomic theory of chemistry, noticed by Sylvester and Clifford (Amer. Jour. of Math., 1878). They represent invariants and covariants by symbolic products arising from the combination of the symbols of the given algebraical forms, and they apply the same symbolic products to represent the constitution formulæ of chemical compounds and radicals. An element-atom and a quantic of the same degree as the valency of the atom are represented by the same symbol; thus $c_x c_x c_x c_x$ or c_x^4 is the symbolic expression for the biquadratic form and also the carbon atom. Symbolic products are formed by combining and enclosing in brackets a pair of symbols, as $(c\,h)$ is formed from c_x and h_x; to this corresponds the process of saturation of valency, $(c\,h)c_x^3$ representing the radical $-\overset{|}{\underset{|}{C}}-H$. For example, the symbolic product $(c_1c_2)(c_2c_3)(c_1h)^3(c_3h)^2(c_1h)^2(c_3o)(o\,h)$ represents the constitution of primary propylalcohol and an invariant of the corresponding quantics, viz., the biquadratic, quadratic, and linear forms. The presence of a complex (θ) of symbolic factors (called the *reducent*) affords a convenient way of dividing chemical compounds into classes and subclasses, each class being characterised by its reducent.

When the process of combination is applied a given number of times to two given covariant forms, a series of symbolic products arises, called *equivalent* in the invariant theory, just as a series of isomers arises from two given radicals: as an invariant may break up into factors, so may an isomer break up into groups of molecules. If two members of the series are known the intermediate members can be interpolated by interchanging two symbols with one another in a pair of symbolic factors, as by interchanging c_1 and c_2 we pass from $(c_2c_3)(c_1h)$ to $(c_1c_3)(c_2h)$; this process is compared with the process going on in chemical reactions. The process of deriving chemical compounds from given compounds is also compared with the processes of direction and transvection, isomers appearing as members of a transvection.

The symbolic representation is applied to the grouping and derivation of actual chemical compounds; three classes of forms with open reducents, leading to the ethyl, ethylene, and ethenyl series of compounds with their alcohols, ethers, acids, amides, ketones, &c., are discussed; the analogy of invariants with closed reducents to the aromatic compounds is exhibited, and finally the symbolic method is applied to an analysis of the indigo formula. W. E. T.

§ 528. *Stassfurt Salt Deposits and the Maximum Tension of Solutions.* **J. H. van't Hoff** and **H. v. Euler-Chelpin.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 46. pp. 1018–1022, Nov. 15, 1900.)—The present paper contains an experimental determination of the maximum tension at 25° of solutions of different sulphates and chlorides of magnesium, potassium, and sodium and mixtures of these, each solution being saturated with sodium chloride. The

results are given in a long table in the paper, first for sodium chloride alone, then for solutions of sodium chloride and one other salt, then sodium chloride and two salts, and lastly for sodium chloride and three other salts. The results are then represented in an interesting triangular diagram, the three sides of which correspond to absence of sulphates, magnesium, and potassium respectively.

The present measurements confirm the formation of a lower hydrated form of gypsum, and also the formation of "Kainite" ($MgSO_4 . KCl . 3H_2O$) at 25°.

[For former papers on the Stassfurt salt deposits see Abstracts Nos. 226, 1114, 1116, 1879 (1900).] J. B. H.

529. *Physico-chemical Studies of Tin. III.* **E. Cohen.** (Zeitschr. Phys. Chem. 35. pp. 588–597, Dec. 7, 1900.)—Stockmeier describes a case of "tin-plague" at Rothenburg, where during the winter of 1893 the dipped tin-plate of the roof of the post office was attacked, whilst the rolled tin-plate of the town hall escaped, and quotes a statement of Lewald to the effect that the crumbling of tin is due to a strain in the material, and only occurs in block tin, and not in rolled tin. This is incorrect, since tin filings are changed into grey tin by long cooling. Since 1893, although the winters have been less severe, the rolled tin of the Rothenburg town hall has also become "infected," and grey tin has begun to appear. In order to ascertain the effect of vibration, a plate of tin was kept at a temperature between 5° and 12°, and rattled continually during three months, but did not undergo change. The maximum velocity for the conversion of white tin into grey tin was previously found to occur at −45°, but this temperature is largely affected by the previous treatment of the tin and by the presence or absence of "pink-salt" in the dilatometer. In presence of a 10 per cent. solution of "pink-salt" the maximum velocity of change in a sample of white tin, prepared by warming grey tin, occurs at 0°, whilst with no "pink-salt" it is at about −45° C. [See further Abstracts Nos. 878 and 1517 (1900).] T. M. L.

530. *Demonstration of Electrolytic Solution-pressure.* **W. Palmaer.** (Zeitschr. Elektrochem. 7. pp. 287–289; Discussion, pp. 289–290, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesell. at Zürich, Aug., 1900.)—Owing to its small solution-pressure mercury becomes positively charged even in contact with an N/2000 solution of a mercurous salt. This charge is acquired by the removal of mercury ions from the solution, and if mercury is sprayed into the solution the latter becomes poorer in mercury at the point where the spray enters. The surface of the mercury at the bottom of the vessel is already in equilibrium with the solution, and the positive charge is therefore given up to the solution, which thus becomes richer in mercury. This difference of concentration can be demonstrated by forcing mercury through a large number of minute apertures and allowing it to fall through a mercurous solution contained in a vessel designed to prevent the mixing of the solution. The concentrations found were in the proportion of 0·51 : 1 : 1·41 at the top, middle, and bottom of the vessel, and similar changes of concentration were found in the case of the anion. [See also Abstract No. 1226 (1899).] T. M. L.

531. *Vapour-pressure Relations in Mixtures of Two Liquids. III.* **A. E. Taylor.** (Journ. Phys. Chem. 4. pp. 675–689, Nov., 1900.)—The measurements already described have been used in order to ascertain whether

Henry's law and van't Hoff and Raoult's law of the decrease of vapour-pressure hold good for mixtures of acetone and water.

Henry's law as to the proportionality of the partial pressure (p) of one component with its concentration (c) in the solution, does not hold good. In the case of the water p/c is fairly steady only at low concentrations, but $p/\sqrt{c}$ is moderately constant up to a fairly high concentration, showing that polymerisation occurs, and that double-molecules of water are probably present in the solution, together with simple molecules, and possibly with molecules of still greater complexity. In the case of the acetone $p/\sqrt[3]{c}$ is most nearly constant, and the degree of polymerisation is evidently greater than in the case of the water. Large deviations occur in the formulæ for acetone and for water when these are present in the solution in an excessively large proportion.

The van't Hoff-Raoult formula allows of the prediction from the composition and vapour-pressure of the solution of the composition of the vapour; the calculated and observed values only differ by a small percentage, and are probably within the limits of experimental error. But when the vapour-pressure is calculated from the composition of the solution and of the vapour the experimental errors in the latter are so magnified that large discrepancies occur. [For preceding parts see Abstract No. 2063 (1900); *cf.* also following Abstract.] T. M. L.

532. *Vapour-pressure of Binary and Ternary Mixtures.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 35. pp. 459–479, Nov. 20, 1900. Communicated in outline to the Königl. Akad. der Wiss. Amsterdam, April 21, 1900.)—The composition of the vapour-phase in contact with two liquid phases containing phenol and water has been determined at different temperatures; the percentage of phenol increases from 5·96 per cent. at 29·8° to 8·66 per cent. at 64·4°, but is always less than the percentage of phenol in the aqueous layer; on distilling at constant temperature, therefore, the aqueous layer will gradually decrease, and the vapour-pressure will remain constant until only the phenolic layer remains.

The composition of the vapour-phase in contact with a single liquid phase has also been determined at different temperatures. The composition of vapour and liquid are identical for solutions containing 5·5 per cent. phenol at 56·3°, 7·2 per cent. phenol at 75·0°, and 8·29 per cent. phenol at 90°; such solutions distil unchanged; solutions containing larger amounts of phenol give a distillate containing less phenol than the solution, and would therefore be concentrated by distillation; the converse holds for solutions containing less phenol.

The total vapour-pressure, P, and the percentages of phenol, x_v and x_s, in the vapour and solution are related by van der Waals' equation—

$$\frac{dP}{dx_v} = \frac{P(x_v - x_s)}{x_v(1 - x_v)};$$

satisfactory agreement between theory and experiment was observed on calculating ΔP from the observed values of x_v and x_s.

In the case of aniline and water the composition of the vapour-phase is intermediate between that of the two liquid phases, where these are present. At 56·3° and at 75° aqueous solutions of aniline were found to contain a much smaller percentage of aniline than the vapour in contact with them. As before, satisfactory results were obtained on calculating ΔP from x_v and x_s.

Values are also given for the vapour-pressures of ternary mixtures of water, phenol, and aniline at 56·3°. [*Cf.* preceding Abstract.] T. M. L.

533. *Determination of Distribution of the Current on the Surface of Electrodes.* **K. Norden.** (Zeitschr. Elektrochem. 7. pp. 309–313; Discussion, pp. 313–315, Nov. 22, 1900. Paper read before the Deutsch. Elektrochem. Gesell. at Zürich, Aug., 1900.)—The author states that if the determination is attempted simply with two opposed electrodes, no satisfactory results are obtained. By intercepting a third electrode, more satisfactory results are found, as the opposed surface in this case acts as a separate electrode. Early experiments by A. Tribe [Phil. Mag. (5) 11, 1881], G. Wiedemann, and particularly J. Stark [Wied. Ann. 66. p. 245, 1898, Abstract No. 301 (1899)], are referred to.

Heinz (Zeitschr. Elektrochem. IV. p. 527) has also employed a similar device for experiments on polarisation.

Sulphate of copper solution, with an intermediate very thin insoluble plate, or a mixed electrolyte of zinc and copper sulphate, in which latter case a very characteristic gradation of various shades of brass deposits are obtained, are recommended. Most characteristic and satisfactory results were obtained when the intermittent electrode was placed in an inclined position. Some reference is made to the question of accumulator plates.

O. J. S.

534. *Electrolytic Lead Bisulphate.* **K. Elbs** and **F. Fischer.** (Zeitschr. Elektrochem. 7. pp. 343–347, Nov. 29, 1900.)—The preparation of lead bisulphate, $Pb(SO_4)_2$, by chemical methods is unsatisfactory and difficult, but the compound is readily obtained as a nearly white, insoluble precipitate by the electrolysis of sulphuric acid of sp. gr. 1·7–1·8, using lead electrodes and a current density of 2–6 amperes per square decimetre. The temperature should not rise above 30°, otherwise more or less decomposition of the bisulphate will occur. Lead bisulphate is soluble in concentrated sulphuric acid to the extent of about 0·3 per cent.; it is instantly decomposed by water with the formation of sulphuric acid and lead peroxide. The chemical reactions of lead bisulphate and some compounds of it with other sulphates are described in the paper, much of which is mainly of chemical interest. This compound is, however, of significance in the theory of accumulators, as has previously been pointed out [see Abstract No. 1743 (1899)]. For if, in consequence of an insufficient degree of porosity in the active material, or of the use of too strong a charging current, the sp. gr. of the acid in the interstices of the positive plate rises above 1·65, lead bisulphate is formed, and the production of lead peroxide is prevented. A portion of the bisulphate, moreover, acts on the lead plate with the formation of ordinary lead sulphate.

N. L.

535. *Electrolytic Production of Benzidine.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 320–328, Nov. 22; and 333–338, Nov. 29, 1900.)—The author arrives at the following conclusions:—(1) In forming benzidine electrolytically in an acid solution, the rate of change from intermediately formed hydrazobenzene bears a direct relation to the rate of reduction. (2) If an acid reduction is attempted nitrobenzene cannot be employed, as the intermediate products, such as phenylhydroxylamine, much decrease the yield of benzidine. (3) As a starting-point for acid reduction, azo- or azoxy-benzene, both of which can be easily prepared by electrolysis, should be used; these on further reduction yield benzidine with an excellent efficiency of 80 per cent. (4) Mercury kathodes are most suitable for all these operations. The stirring of the electrolyte is of importance as regards yield. [See also Abstract No. 186 (1901).]

O. J. S.

536. *Sterilisation of Water by Ozone.* **Thomæ.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1685–1688, Dec. 8, 1900.)—The author gives a general summary of the progress made in generating ozone by the electrostatic method, and enumerates the various forms of ozoniser that have been given designed for this purpose. He then gives a detailed account of the exhibit of the "Société industrielle de l'ozone" at the recent Paris Exhibition. This Company now owns the Marmier and Abraham patents, and has two installations at work, namely, at Lille and at Boleo in Mexico. In the latest form of ozoniser hollow electrodes are used, cooled by water. Glass is used as dielectric, with a pressure of 40,000 volts. The author considers that the cost of sterilising by this method, namely, 0·01 frc. per cub. metre, requires confirmation. The report of the Lille Medical Commission is finally quoted. [See Abstract No. 1755 (1899).] J. B. C. K.

537. *Haas and Oettel's Electrolytic Bleaching Apparatus.* **F. Oettel.** (Zeitschr. Elektrochem. 7. pp. 315–320, Nov. 22, 1900.)—A rectangular box is divided into compartments by means of vertical carbon electrodes fitting into recesses. The negative end-electrode consists of a stout lead plate, and the intermediate bi-polar electrodes of specially prepared carbon plates 1 c.m. thick, the positive end-electrode being formed by two such plates. A current density of 1,000 amperes per square metre is employed, the electrodes being totally immersed so that no chlorine is given off on the surface. Any loose carbon dropping down settles at the bottom. A brine solution of density 5° Bé. forms the electrolyte which passes alternately over the top and under the bottom end of the carbons. By noting the increase of temperature between the electrodes, and the flow of liquor, the quantity of hypochlorite formed is checked.

The whole apparatus can be tilted on one side, cleaning thus being facilitated. If strong hypochlorite solutions are required, artificial cooling must be applied.

With an initial concentration of 2·55 gr. per litre, and a current of 61 amperes per apparatus, the amount of power expended per kg. of chlorine was 4·48 h.p. hours. With a run of ten hours, 14·31 grs. per litre were obtained for an expenditure of 8·11 h.p. hours. These strong hypochlorite liquors render it a feasible project to introduce the apparatus into paper-works. O. J. S.

538. *Electrolytic Oxygen and Hydrogen for Industrial Purposes.* **O. Schmidt.** (Zeitschr. Elektrochem. 7. pp. 295–298; Discussion, pp. 298–300, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesells. at Zürich, Aug., 1900.)—The general form of apparatus used for the electrolytic decomposition of water upon a practical scale consists of an iron vessel with iron electrodes, into which an alkaline electrolyte is fed. At the anode the iron assumes the passive molecular condition, and oxidation only occurs when the current density or the concentration of the electrolyte is too high.

The more commonly known electrolysers have, however, many disadvantages, and the author has brought out an improved form. It is based upon the filter-press principle, and consists of a number of narrow, square iron frames, each separated from its neighbours by asbestos cloth, and each containing an iron electrode. Any number of these frames can be built up to form one many-celled electrolyser. The current passes from one cell to the next by the double pole iron electrodes, and the hydrogen and oxygen liberated in each cell division are separately collected and stored in two gas-

holders attached to the apparatus. This improved form of electrolyser is said to be already adopted in several small establishments where oxygen and hydrogen are used for various purposes. The e.m.f. required to work it is 2·5 volts, and a yield of 168 litres of hydrogen and 84 litres of oxygen per kw. hour can be obtained. This represents an energy efficiency of 54 per cent. The gases obtained are not quite pure ; the oxygen contains 2 per cent. of hydrogen, and the hydrogen 1 per cent. oxygen, but for industrial use these percentages are unimportant. Oxygen and hydrogen produced by electrolysis are already being employed in accumulator works for burning lead joints ; electrolytic hydrogen is being used for inflating military balloons, and may find a wide field of employment as a lighting agent. Burnt in a suitable burner, hydrogen is a cheaper illuminant than acetylene, the relative costs for equal illuminating power being as 25 to 59. The chief difficulty which hinders the adoption of compressed hydrogen as a lighting agent is the cost of transporting the steel cylinders in which it is stored and sold. Hydrogen is also one of the cheapest carriers of energy for power purposes, Borchers having shown that 1-h.p. hour generated from electrolytic hydrogen will cost only 3·02 pfge., as compared with 3·82 pfge. when acetylene gas is used.

The author at the conclusion of his paper showed several Auer incandescent burners fed with hydrogen in place of coal gas, and stated that these burners would yield 672 candle-hours per kw. of electrical energy used in the production of the hydrogen, as compared with 666 candle-hours for the same energy used in the new Nernst glow-lamp.

Nernst, who joined in the discussion upon this paper, gave his reasons for doubting some of the statements made by the author. J. B. C. K.

539. *Electrolytic Oxygen and Hydrogen.* **Buffa.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 305–344, Sept. 30, 1900.)—In this lengthy memoir the author discusses the industrial electrolysis of water under five sections, dealing with—Electrolytic Cells, Chemical Changes, Industrial Installations, Industrial Yields, and Applications, respectively. In Section I. he describes the cells of Renard, Garuti, and Del Proposto. The first used diaphragms of asbestos, the others metallic diaphragms which have proved more satisfactory. These are of thin sheet steel, it having been found that below pressures of 3 volts these sheets act as diaphragms, and not as secondary electrodes as one would have expected.

The electrolytic works at Rome, designed by Bossi and Bassani for the production of hydrogen for inflating military balloons, are described in Section III. These works are operated by alternating current at 2,000 volts from the generating station at Tivoli, 27 km. distant. This current is transformed in the works to direct current at 50 volts. The decomposing cells are 51 in number and are of the Garuti type. They are worked in three parallel series of seventeen each, each series taking 400 to 450 amperes at 45–50 volts. A 14 per cent. sodium hydrate solution is used with iron electrodes. A film of oil is employed to cover the surface of the electrolyte.

Section IV. deals with yields and costs, and it is stated that at Rome 1-h.p. hour measured at the terminals of the primary circuit of the transformer yields 0·086 c. metre hydrogen gas. At Brussels 1-h.p. hour measured at the terminals of the decomposing cell yields 0·12 c. metre hydrogen. At Rome the kw. year costs 96·6 frcs., and the cost of 1 c. metre of hydrogen and ½ c. metre of oxygen is 20 cents, interest and depreciation charges excluded. The cost of a 100-h.p. installation, with the necessary pumps for compressing the gases produced, is estimated at 110,000 frcs.

In Section V. the author discusses the various applications of the gases duced by the electrolysis of water. These are as follows: Soldering als by the oxyhydrogen flame, soldering aluminium, soldering accumulator es, repairing the tubes of water-tube boilers, soldering trolley wires, use hydrogen for military purposes, use of oxygen for medical and surgical k, illumination by the oxyhydrogen light, heating by the oxyhydrogen wpipe furnace, melting glass by the oxyhydrogen flame, and use of drogen in gas-motors. J. B. C. K.

540. *Electrolytic Regeneration of Chromic Acid Solutions and Manufacture Diaphragms.* **M. Le Blanc.** (Zeitschr. Elektrochem. 7. pp. 290–295; cussion, p. 295, Nov. 15, 1900. Paper read before the Deutsch. Elektro-m. Gesells. at Zürich, Aug., 1900.)—Acid solutions of sodium bichro-te are much used in the organic chemical industry as oxidation reagents. e method generally adopted for regenerating these solutions after use is a mical one, and is both troublesome and wasteful.

Fitzgerald was the first to patent an electrolytic method for effecting this eneration, but his process, patented in 1886, was unsatisfactory, and has en way to an improved electrolytic method now in use by the "Höchster bwerke." The spent chromic acid solution is placed in the anode and hode chambers of a diaphragm cell. The anode liquid is oxidised, and ns in sulphuric acid; the kathode liquid loses in acidity, and hydrogen is erated. After a definite interval of time the kathode liquid is transferred the anode chamber of the cell, and more spent chromic acid solution is rged into the kathode division. The process is therefore a cyclic one, l no loss of acid or of chromium compounds occurs. A 70–90 per cent. dising current efficiency can be attained in the anode chamber, with an .f. varying between 2·7 and 4·0 volts. Lead anodes are used, this metal ing better results than platinum. The only difficulty in connection with s process is in the manufacture of durable diaphragms of low electrical istance. Without diaphragms the current efficiency of the cell sinks to y 10 per cent. at 15° C., and electrochemical methods of avoiding the cessity for diaphragms have proved unworkable in practice. The author scribes at length the different steps by which the present method of nufacturing the diaphragms for the "Höchster Farbwerke" was evolved. The composition used in their manufacture after firing at 1,000° C. ntains 75 per cent. SiO_2 and 25 per cent. Al_2O_3. Plates measuring) × 970 × 7 mm. have been made from this mixture, which can also be rked up into cylinder form. These diaphragms have proved themselves be remarkably resistant to chromic acid solutions, one diaphragm having en in use over one year without any visible deterioration. The electrical istance of the diaphragms is small, the loss of pressure with a current of) amperes per sq. metre at 20° C. being only 0·15 to 0·20 volt. The German n of Villeroy & Boch have taken up the trade manufacture of these phragms.

A short discussion followed the reading of this paper. J. B. C. K.

541. *Electrolytic Chlorate from Calcium Chloride Solutions.* **S. A. Tucker** d **H. R. Moody.** (Soc. Chem. Ind., Journ. 19. pp. 977–981, Nov., 1900. per read before the New York section of the Society, Oct. 19, 1900.)—The hors desired to find whether any industrial process could be devised for ling with the large amount of calcium chloride obtained in solution as a product in the ammonia soda industry. The results obtained in the course

of 67 experiments are given in tabular form, and the conclusions drawn from these experiments are summarised as follows: (1) The highest yields of chlorate are obtained with an electrolyte containing 20 per cent. calcium; (2) the electrodes should be of platinum, horizontal, and about 10 cm. apart; (3) the best current density to employ is one of 8 amperes per sq. dcm. measured at the anode; (4) the best results are obtained at a temperature of 80° C.; (5) the addition of sodium bichromate, or sodium hydrate, to the electrolyte increases the efficiency of the cell; (6) working under these conditions it is possible to obtain very high current efficiencies in the cell even with prolonged periods of working, the fall in efficiency during a run of 49 hours being equal to only 11 per cent. J. B. C. K.

542. *Progress of the Aluminium Industry.* **Héroult.** (Ind. Électrochim. 4. pp. 81–83, Aug., and 89–90, Sept., 1900. Reprint of a paper read before the "Congrés International des Mines et de la Métallurgie," 1900.)—The author gives some figures showing the increase of production and fall of price in this industry since 1886. The present output he estimates at 5,000 tons, and one-half of this he states is used in steel works. The use of aluminium for electrical conductors he believes to have a great future before it. In connection with the improvements in the process of extracting aluminium from alumina, he names Lontin, Grabau, Minet, Kleiner, Cowles Bros. and Hall, and then passes on to a detailed account of the experimental work which led up to his own process for aluminium manufacture. The chemical changes involved in the operation of this process are also fully dealt with. The paper concludes with a list of the works in Europe and America now producing the new metal, with the names of those responsible for their financial and technical management. J. B. C. K.

543. *Poulenc and Meslans' Apparatus for the Manufacture of Fluorine.* **Brochet.** (Électricien, 20. pp. 273–275, Nov. 3, 1900.)—This apparatus is based on Moissan's discovery that copper may be used in place of platinum for the construction of the electrolytic vessels and tubes for the production of fluorine [*cf.* Abstract No. 2072 (1900)]. The containing vessel is of copper, with a cover and tube to remove the hydrogen liberated; within is a rectangular copper vessel serving as an anode chamber, the walls of which at the lower part are perforated with V-shaped holes, so that it plays the *rôle* of a porous diaphragm. The anode consists of a long narrow copper-box covered on two sides with platinum plates. Connected metallically with the upper part of the anode chamber is a metallic tube for the removal of fluorine. The whole vessel is immersed in a freezing mixture, and a cooling liquid is constantly circulated through the hollow anodes. The anode chamber is insulated from the outer kathode vessel by a layer of caoutchouc, but this material in no place comes in contact with fluorine. The electrolyte is a solution of potassium fluoride in anhydrous hydrofluoric acid, and the contamination of the generated hydrogen and fluorine by hydrogen fluoride is prevented by passing these gases severally through tubes surrounded by freezing mixtures. Two forms of apparatus are described, one for industrial, the other for laboratory use. They form the subject of a patent, and were shown in the Paris Exhibition. W. G. M.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

544. *Relative Efficiency of Triple and Quadruple Expansion Engines.* **A. L. ellanby.** (Mech. Eng. 6. pp. 764–769, Dec. 1, 1900. Paper read before : Manchester Association of Engineers, Nov. 24, 1900.)—The object of this per is to show by actual trials the consumption of triple and quadruple pansion engines working under similar conditions, and to determine why e type should be more economical than the other.

The trials were made at the Durham College of Science, Newcastle-on- ne. The quadruple engines had cylinders 7″, 10½″, 15½″, and 23″ by 18″ oke ; the triple engine had cylinders 7″, 10½″, and 23″ by 18″ stroke, or 7″, ½″, and 23″ by 18″ stroke. The power of the engine was absorbed by a oude hydraulic brake.

The point of maximum economy with the quadruple engine was reached nen the cut-off in the h.p. cylinder was about two-thirds and the total mber of expansions about 17·4. In the triple engine the trials with the aller m.p. cylinder gave the better results. The quadruple engines always nsumed less water than the triple engines, but the triple engines gave a ich higher mechanical efficiency than the quadruple set, and that through much greater range.

Considerable changes in consumption could be effected by altering the t-off in the m.p. cylinder while leaving the cut-off in the h.p. unchanged. the pressure in the first receiver drops, the consumption of water rises. e reason for this increase is partly due to the smaller amount of cushioning ere is in the h.p. cylinder, and therefore more steam is required to fill m. Initial condensation only accounts for a small proportion of this crease ; the greater proportion of it is due to leakage past the valves, nsequent on the greater difference of pressure. The back pressure of the . cylinder should therefore be kept as high as possible. Up to the limiting essure of the experiments, viz., 210 lbs. per square inch, there appears be very little advantage in the quadruple over the triple engine, but the lve leak seems to have had considerable effect in the economy. L. S. R.

545. *Test of Allis Triple Expansion Pumping Engine.* (Eng. News, 44. . 125–126, Aug. 23, 1900.)—The engine is vertical, with triple expansion, ning at 17½ r.p.m., and having a capacity of 30,000,000 U.S. gallons in enty-four hours. The cylinders were all jacketed, and the receivers were ed with reheating coils between the h.p. and i.p., and between the i.p. and . cylinders. The arrangement of jackets and coils and the circulation of am through them are fully described. The surface condenser has 00 square feet of cooling surface, and is fitted with an exhaust feed- ter heater, having 300 square feet of heating surface between the l.p. haust and the condenser.

The contract was a duty of 150,000,000 ft. lbs. for each 1,000 lbs. of dry am supplied to the engine. The cylinders are 30″, 56″, 87″ diameter

and 66″ stroke. The diameter of the plungers is 42″. Grate surface of boiler 63·87 square feet; heating surface, 2,849 square feet; ratio, 1 to 44·6.

Duration of trial	24	hrs.
Boiler pressure, mean	187·37	lbs.
Temperature of gases leaving boiler	485·4°	Fahr.
,, ,, ,, economiser	221·9°	,,
Total i.h.p.	801·5	
Average steam per i.h.p. per hr.	10·48	lbs.
Coal per hour per sq. ft. of grate surface	12·8	,,
,, ,, ,, of heating surface	0·287	,,
Evaporation per lb. of coal from and at 212°	12·47	,,
Coal per i.h.p. hour	1·02	,,
Duty per 1,000 lbs. steam (contract value 150,000,000 ft. lbs.)	176,051,500	ft. lbs.
Efficiency of mechanism	93·20	per cent.
,, ,, boiler and economiser	85·9	,,
,, ,, ,, alone	80·3	,,
Thermal efficiency of engine	21·63	,,

L. S. R.

546. *Liquid Fuel.* **E. L. Orde.** (Mech. Eng. 6. pp. 775–777, Dec. 1, 1900. Paper read before the North-East Coast Institution of Engineers and Shipbuilders.)—Recent increase in the number of places in the East at which crude oil can be obtained makes the use of liquid fuel an important question for ships trading to the eastward. Experiments were made by the author with crude Borneo oil of the composition :—Carbon, 87·9 per cent.; hydrogen, 10·78 per cent.; oxygen, 1·24 per cent.; flash-point, 211° Fahr.; boiling-point, 395° Fahr. Calorific value by bomb calorimeter, 18,831 B.T.U.

The various constituents of fuel oils give off vapour at temperatures varying from 100° Fahr. up to the boiling-point of the oil, near which point a residue of solid carbon is formed tending to choke up pipes or passages and to accumulate in the furnace.

The following methods of using liquid fuel are referred to :—(1) Injecting the oil under pressure through a nozzle as spray into the furnace. (2) Spraying the oil by means of air or steam under pressure. (3) Vaporising the oil.

The evaporative efficiency found by the author under the first plan was about 12 lbs. of water from and at 212° Fahr. per lb. of oil : a large excess of air and large furnace space were required for combustion. Under the second, 13 to 14 lbs. from and at 212° Fahr., less air being required. Under the third, with a plan of the author's, 15 to 16 lbs. from and at 212° Fahr., a minimum of air being required, and the waste gases showing the following composition :—

Analyses of Waste Gases.	I.		II.	
Carbon dioxide	13·2	per cent.	12·6	per cent.
Oxygen	3·6	,,	4·0	,,
Carbon monoxide	0·0	,,	0·0	,,
Hydrocarbons (Olefines, &c.)	0·0	,,	0·0	,,
Hydrogen	0·0	,,	0·0	,,
Nitrogen	83·2	,,	83·4	,,
	100·0		100·0	

The appearance of the flame at a few inches from the nozzle suggested t the hydrocarbons were burning in the form of acetylene.
The general conclusions arrived at by the author are :—(1) A reduction in nsumption of fuel, with Borneo oil as compared with coal, of about 40 per nt. (2) A reduction in bunker space of about 15 per cent. for equal weights uel. (3) A reduction in the stoke-hold staff of at least 50 per cent.
The author recommends filtering the oil in all cases to prevent accumula- n of dirt in the burning apparatus. F. J. R.

547. *Steam Engine Indicator Tester.* **C. A. Read.** (Mech. Eng. 6. 832–833, Dec. 15, 1900. Paper read before the American Society of chanical Engineers, N.Y., Dec., 1900.)—A description of an arrangement apparatus for the so-called dynamical testing of steam-engine indicators. e drum of the indicator is actuated by a cord attached to a lever on the ee-way cock. The cock is rotated at any required speed, and puts the icator into communication with two reservoirs alternately. The pressure the reservoirs is determined by means of a [presumably dead-weight] ge-tester. The two lines traced on the card should be horizontal and at a tance apart which represents the difference of the pressures in the ervoirs. H. R. C.

GAS AND OIL ENGINES.

548. *Engines for Blast Furnace Gas.* **A. Wagener.** (Zeitschr. Vereines utsch. Ing. 44. pp. 1517–1524, Nov. 10, and 1568–1572, Nov. 17, 1900.)—is paper describes various gas engines supplied to the Hoerder Bergwerks l Hüttenverein for use with blast furnace gas, and tests on them carried out the author. The engines are of the Oechelhaeuser and Junkers type, ing one impulse every revolution. The cylinder has two pistons, working opposite directions, off cranks on the main shaft. The in- and out-let ts are opened and closed by the pistons themselves. A double-acting pression pump drives mixture into the main cylinder from one side of its ton, and from the other drives air through the cylinder immediately after exhaust is opened. The 600-h.p. engine, built by the Berlin-Anhaltische schinenbau Aktien Gesellschaft, has two cylinders, each 675 mm. in meter. Its speed is 125 r.p.m., and its possible overload 20 per cent.
Analyses of the blast furnace gas over a period of sixteen days showed a an composition in volumes per cent. of CO 31·2, H_2 2·0 and CO_2 9·1. The an calorific value, as measured in Junker's calorimeter, varied from 950 to calories per cubic metre of gas at 0° C. The volume-ratio of gas to air he mixture which produced most complete combustion was found to be 3. The residual gas showed on analysis 0·7 per cent. CO as the only com- tible. The limits of inflammability were reached with ratios of gas to air 1 : 6 and 4 : 1·5. The consumption of gas by the above-mentioned 600-h.p. gine was slightly over 3 cubic metres per h.p. hour.
The preliminary trials made with other engines, and the means employed overcome various defects, are described in detail. Scale drawings and illus- ions of the engines are also included in the paper. G. H. B.

549. *Bánki Oil Engine.* **E. Meyer.** (Zeitschr. Vereines Deutsch. Ing. pp. 1056–1063, Aug. 11, 1900.)—The Bánki engine in its 20 h.p. size, as strated in this paper, is of the vertical type, and draws oil into the cylinder he form of a spray. Its essential difference from other motors of a similar

type is that water is drawn into the cylinder together with the charge of oi and air in order to cool the cylinder and permit the use of higher com pression pressures. The following table gives the result of tests made on th engine :—

Horse-power	26·4	20·7	15·1	8·2
Kilos of benzine per h.p. hour	0·221	0·235	0·261	0·326
Ratio, weight of water to weight of benzine	4·84	3·30	2·82	2·33

Compression pressure, 16·4 kg. per sq. cm. ; explosion pressure, 38 kg. per sq. cm. ; ratio of total cylinder volume to compressed volume, 9·8.

The greater part of the paper consists of calculations, based on theoretica grounds, of the economy effected by the introduction of water. The autho was not able to ascertain experimentally to what extent the water was gasified on its introduction into the hot cylinder and before compression ; he does not however, think that the vaporisation can be complete. The calculations therefore are made for the two extreme cases, assuming no vaporisation of the water, and assuming its complete vaporisation. Again, since no exact figures are available giving the variation of specific heat of gases with the temperature at high temperatures, the calculations are made for two cases : firstly, assuming the specific heat constant, and secondly, taking Mallard and le Chatelier's figures, which the author considers give too great variations. The compression ratio possible with water-jet is taken as 9·6, and without as 4·0. The following are the results of the author's calculations :—Assuming the specific heat to be constant, the use of a water-jet increases the efficiency by 25 per cent. if the water be vaporised, and by 11 per cent. if liquid ; assuming the specific heat variable, it increases the efficiency by 28 per cent. if the water be vaporised and by 23 per cent. if liquid. G. H. B.

AUTOMOBILISM.[1]

550. *Novel Automobile Steam Engine.* (Horseless Age, 7. pp. 76–78, Nov. 7, 1900.)—The engine of A. J. Peet, of New York, is described, in which four single-acting vertical cylinders, two h.p. and two l.p., are arranged so that their connecting rods actuate a quadrilateral pyramid pivoted at the centre of its base. At the apex of the pyramid is fixed a pin, the projection of which fits into a bushed lug on a bevel pinion fixed to a vertical shaft. This pinion gears with a bevel wheel at the end of a horizontal shaft which replaces the crankshaft of the ordinary engine. The engine described is intended for a steam automobile and develops 4 h.p. It weighs 100 lbs., and the cylinder dimensions are $2\frac{1}{8}$-inch and $4\frac{7}{8}$-inch bore by $3\frac{1}{4}$-inch stroke. Diagram illustrations are given. C. R. D'E.

551. *French Automobile Trials.* **G. A. Burls.** (Automotor Journal, 5 pp. 80–81, Nov., 1900.)—The author summarises the results of the trials which took place at Vincennes in connection with the Paris Exhibition. The competing vehicles were divided into two classes, "light" and "heavy." In the former class the vehicles ran a total of about 190 miles through Paris on six consecutive days, and the heavy vehicles ran about 40 miles per day in two stages for a similar period. The light vehicles carried loads of from 2 cwt. to 5 cwt., and the heavy vehicles from 1 ton to 2 tons. Separate consump

[1] Electric Automobiles are described in the section dealing with Electric Traction.

n trials over a level road for 12·9 miles furnished the results tabulated ow :—

Maker's Name.	Gross in Tons.	Average Speed m.p.h.	Gross Ton-Miles.	Consumption per g.t.m.		
				Petrol in Pints.	Coke in lbs.	Water in lbs.
ter.....	2·76	9·18	35.6	—	—	—
nhard lurry.....	4·42	11·30	57·0	0·228	—	—
nhard omnibus	4·53	9·25	58·5	0·455	—	—
Dietrich.....	4·23	10·37	54·7	0·242	—	—
ugeot	2·36	9·50	30·4	0·289	—	—
Dion lurry.....	—	12·80	—	—	—	—
rgan & Foy	4·83	13·70	62·3	—	2·12	11·6
ntz	3·17	7·70	40·8	0·345	—	—

The author considers that the trials suffered from a lack of thoroughness organisation, and that the results possess no great accuracy ; he also calls tention to the unwise tendency of the French drivers to run their heavy hicles too fast. C. R. D'E.

552. *The Automobile Manufacturing Company's Steam Carriage.* (Automotor rnal, 5. pp. 107–111, Dec., 1900.)—This vehicle is fitted with a flash type boiler, a furnace burning ordinary kerosene, an oscillating and double-ing engine which drives direct on to the rear axle, a condenser for saving t of the feed-water, and a reheater for rendering any uncondensed steam isible. The whole system employed has many interesting and novel tures ; these are fully described and are illustrated in detail in this article. experimental car, which has already been built, is first dealt with, and s is followed by a description of a later design, which is now in course of nstruction. In the latter vehicle the boiler consists of eight coiled double bes, into each of which the water is forced by a pump and by an auto-tic regulator. The boiler is fixed in the front of the car, and the steam is en from each of the tubes through a common pipe to a distributing and ersing valve behind the back seat. The boiler is normally fed with rosene, which passes through a vaporising coil above the boiler tubes. e feed of the fuel into the burner is controlled by a needle-valve, which gulates the size of a passage through an air-injecting nozzle. Petrol is used first heating the boiler, and a spirit flame is employed for vaporising the trol. The steam is led to and from the two cylinders, which are double-ing, and which have a bore of 4 inches and a stroke of 8 inches, through rts in the trunnions upon which they oscillate. A variable cut-off valve, the mushroom type, is operated by a cam on the main shaft and can be gulated by hand. Reversing is effected by changing over the steam and haust connections to the trunnions. The exhaust steam passes through a ge condenser underneath the centre of the car to a drum which is con-cted with the top of the water tank by a pipe ; a portion of this pipe is med into a coil which is placed inside the water tank. Another pipe nnects the top of this tank with a reheater above the boiler. The water fed to the generator tubes by means of a force-pump which is always rking when the engines are running. This pump has a constant delivery any given speed, and it is of such a size that it always supplies more

water than is ever required. The water is forced into a cylinder in which a piston provided with springs resists the entrance of the water. The piston is connected with a by-pass valve in such a manner that it returns the water from the cylinder to the suction pipe of the pump as soon as it has been forced outwards a certain distance. The cylinder is in communication with the boiler tubes through a non-return valve, and as the boiler-pressure falls, water passes into the tubes automatically. The normal boiler-pressure can be regulated by adjusting the strength of the springs which act upon the piston. For starting the engines it is only necessary to draw the piston forward against the action of the springs and then to release it; a lever is fitted for this purpose, and can be worked by the driver when necessary.

A. G. N.

553. *Economy in Steam Vehicles.* **E. C. Oliver.** (Horseless Age, 7. pp. 15–17, Nov. 21, 1900.)—After pointing out the low efficiency of existing steam carriages and the expense of gasoline as fuel, the writer looks for improvement in the boiler, in the cylinder design, in the valve gear, and in the transmission mechanism. As there are so few tests of these small machines available, he draws the following conclusions from those made with larger boilers and engines. The relative evaporation of the three types of boiler, per lb. of fuel, are :—Water-tube 8 to 10, fire-tube (return flue) 6 to 8, and locomotive 5 to 6. The first of these is more economical and it is safer. Heating the feed-water, from the exhaust steam and from the waste products of combustion, enables a saving of fuel and a similar increase of boiler capacity to be made; a table giving the percentage of fuel used at various feed-water temperatures, the steam pressure being 70 lbs. per square inch, is given. The question of superheating the live steam is entered into, and a case is quoted in which 11 per cent. less feed-water resulted; the economy of superheating becomes less as the steam pressure is increased and as the cylinder lubrication becomes affected. The writer then discusses the use of steam-jackets round the cylinder and gives an instance in which, with steam at 50 lbs. pressure, considerable economy resulted. On the subject of steam distribution, the writer mentions that with the ordinary link-motion valve-gear a loss of from 15 to 30 per cent. over other methods results; he urges the necessity for a more perfect system for this type of engine. Compound and triple expansion engines are next dealt with, and their advantages are strongly insisted upon when high pressures are employed; the comparative economy over simple expansion is given as 20 per cent. with compound, and 30 per cent. with triple expansion. The convenience of being able to obtain an increased torque by admitting live steam to the lower pressure cylinders is also mentioned. Regarding transmission gearing, perfect alignment, rigid construction, correctly designed bearing surfaces and means for taking up wear are advocated. In summing up, the several sources from which economy may be expected are given in tabular form, and it is pointed out that, although some of these may not be applicable, there is ample field for a reasonable reduction of water consumption. It is possible, if desirable, to build a steam vehicle having a water consumption of 15 to 20 lbs. per h.p. hour; in such an outfit the engine and boiler should be closely related, the steam-pipe short and direct, the engine cross-compounded, both cylinders steam-jacketed with high-pressure steam, the burnt gases should reheat the steam for the low-pressure cylinder, and the feed-water should be heated by the exhaust steam.

A. G. N.

554. *Steam and Gas Engines on Automobiles.* **R. H. Thurston.** (Horseless Age, 7. pp. 40–42, Nov. 7, 1900.)—The main object of this article is said to be to indicate the relative advantages of steam and internal combustion engines for automobiles, but the bulk of the paper reiterates the well-known arguments in favour of automobiles generally and incidentally states that the opportunities for their use is not so great in America as in Great Britain because of the lower cost of railway work and of the greater cost of transit over the inferior roads. Concerning steam and gas engines, it is pointed out that both have undergone, and are still undergoing, radical improvement for this work; in the former, the prime difficulties lie in the safe control and storage of the fuel and in the change-speed transmission gearing; in the latter it is the boiler which is liable to give trouble. The use of the heavy, low-flash oils may yet be possible with internal combustion engines, and it is suggested that the other difficulty may be overcome by the use of a governor, or by the provision of steady pressure for starting. A boiler is wanted which will be safe at high pressures, which will supply any required amount of steam at a constant pressure, will be free from corrosion or incrustation, and will be efficient, light, and small. A. G. N.

555. *The Darracq Petrol Car.* (Locomotion Automobile, 7. pp. 770–774, Nov. 29, 1900.)—This machine is of the high-power voiturette type, and is of a very different design from those originally built by the same maker [see Abstract No. 566 (1900)]. The mechanism is mounted upon a tubular frame and is constructed in five separate parts, any of which can be removed independently by unscrewing four nuts; these parts are (1) the steering-gear, (2) the motor, (3) the radiator, (4) the change-speed gear, and (5) the differential gear and "live" rear axle. The motor is of the single-cylinder, water-jacketed, vertical type, and is placed in front; it develops $6\frac{1}{2}$ h.p. and will run at any speed from 100 to 2,000 r.p.m. The output can be varied over a large range by means of a device which enables the driver to regulate the degree to which the admission valve can open; this adjustment allows of any lift of the valve between $\frac{1}{10}$ mm. and 4 mm. The motor is fixed with its crankshaft at right angles to the axles, and it is provided with a friction-clutch which connects it to a change-speed gear of the sliding toothed-wheel kind. The power is transmitted through a universally jointed shaft to a pair of bevel wheels, driving the rear axle. Three forward speeds and one reverse motion are provided for. The description of the vehicle is accompanied by drawings of the complete machine, of the underframe, of the motor, of the rear axle, and of the speed-gearing. A. G. N.

556. *La Métallurgique Voiturette.* (Locomotion Automobile, 7. pp. 786–788, Dec. 6, 1900.)—A well-illustrated description of a compact Belgian car. The chief features lie in the construction of the motor cylinders and in the arrangement of the whole transmission and differential gear inside a casing, which also forms the crank chamber. A rigid tubular underframe carries all the driving and steering mechanisms; the steering-heads for the front wheels and the bearings for the "live" rear axle are solid with it and the body is suspended upon it by springs. The motor with its gearing is mounted forward of the rear axle and centrally between the back wheels; their oil-tight case also encloses the differential gear on the driving axle. The $4\frac{1}{2}$-h.p. motor is of the vertical double-cylinder type and its cranks are set at an angle of 180°. The valves and the electric-ignition device are of the usual type. The upper part of the cylinders are turned externally so as to taper slightly upwards, and

a cylinder cover, which also contains the inlet and exhaust valves, fits over this tapered surface. That part of the cylinder-cover which fits over the cylinder is turned taper internally and is cut away between its upper and lower facing surfaces in such a way as to form a water-jacket between it and the cylinder wall. The cover is pulled downwards so as to make water-tight joints top and bottom by a screwed ring which fits against a thrust-taking surface on the cylinder wall, and which can be screwed upwards into the cover. That part of the cylinder head which contains the exhaust valve is also cored out to form a water-jacket. The flywheel is fixed outside the crank-chamber, and the crankshaft on that side of the motor is surrounded by a loose sleeve which passes between it and the bearing, and which connects an outside sliding-clutch face with an inside spur-wheel. The flywheel forms the other half of the clutch, and it can thus be coupled to the sleeve or disengaged from it. The spur-wheel on the sleeve meshes with a toothed wheel on a countershaft, which also carries three different sized spur-wheels. These three wheels remain always in mesh with corresponding wheels which are carried upon ball bearings concentric with the rear axle. These latter wheels are in reality merely rings with teeth on their peripheries, with ball races of large diameter on their sides, and with projections which act as clutches on their inner faces ; the central ring-wheel is held in place only by the balls between it and the other two rings. A sliding sleeve, which drives the differential gear, is mounted about the rear axle, and it is fitted with a disc which has projections on its outer edge and which can be moved into engagement with either of the three ring-wheels, thus giving either of three relative speeds to the driving wheels. A. G. N.

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557. *Friction in Machines.* **N. Petroff.** (Acad. Sci. St. Pétersbourg, Mem. 10. pp. 1–84, 1900.)—Chiefly a theoretical investigation.

558. *American Central-valve Engine.* **E. T. Adams.** (Mech. Eng. 6. pp. 874–875, Dec. 22, 1900. Abstract of a paper read before the American Society of Mechanical Engineers, N.Y., Dec. 1900.)—A description of a central-valve engine similar to the Willans, but having the two cylinders side by side instead of tandem ; it is intended to run at only 200 to 300 r.p.m. H. R. C.

GENERAL ELECTRICAL ENGINEERING.

559. *Stretched Wires.* **R. Léon.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 275–304, Sept. 30, 1900.)—The subject of sag and span of wires is considered theoretically. The overload (snow, &c.) per metre required to break the wire is worked out, taking the fall of temperature into account : longer spans will carry very slightly greater aggregate loads than shorter ones. For spans exceeding 200 metres, elasticity of the supports has very little effect. Various problems of wires on a line of posts are worked out. The paper makes free use of graphic diagrams. A. D.

560. *Electric Soldering of Zinc Pipes.* **Calmeau.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 214–229, Aug. 14, 1900.)—The process of the electric welding of iron as it is now usually employed in England and America is first alluded to, and next those of Bernardos and Slavianoff, which are less known in this country and in which the heat of an electric arc is used to melt small pieces of iron which have been placed on the parts to be welded and covered with a suitable flux to prevent oxidation. This method may be extended to other metals than iron, and the author applies a form of it to the soldering of zinc pipes.

After enumerating the various inconveniences attendant on the use of ordinary soldering irons, he describes a new method of his own invention where the soldering iron is heated electrically, by which he avoids these defects. The implement consists essentially of an arrangement in which the usual copper portion of the soldering iron is surmounted by two sections or chambers one above the other, and insulated from one another by a partition of asbestos. The upper section carries a carbon pencil able to be raised and lowered by means of a screw cut on its holder, and is connected with the negative terminal of the source of the electric current, while the bottom of the lower section is formed by the copper portion of the soldering iron, which copper is connected with the positive terminal. The carbon pencil passes through the asbestos partition into the lower section, and being first brought into contact with a slight prominence on the copper and then slightly withdrawn, an electric arc is produced which heats the copper. Should the direction of the current be reversed by connecting the carbon with the positive terminal and the copper with the negative, the carbon and its surroundings become unduly heated, while the copper is scarcely heated at all.

The paper is illustrated by several drawings, and the mode of using the instrument is fully described, for which the original paper may be consulted with advantage. O. J. S.

561. *Electrically Controlled Pneumatic Street Clocks in Paris.* **G. Dary.** (Électricien, 20. pp. 340–342, Dec. 1, 1900.)—In the system employed by *La Compagnie Parisienne de l'air comprimé pour horloges pneumatiques*, the area to be served is divided into sections of 3 km. radius. In the centre of each of these sections is a substation to which the air-pipes of all the clocks extend. This substation is provided with a reservoir containing air at a pressure of 700 grammes per sq. cm. and with a slide-valve which, when in one extreme

position, puts the reservoir into communication with the air-pipes or network of pipes connected to the secondary clocks, and when in the other extreme position, opens the network to the atmosphere. This slide-valve is actuated intermittently by a piston in a cylinder to which compressed air is admitted and exhausted through a slide-valve moved through a link from a pivoted armature arranged between the poles of two electromagnets. These electromagnets are energised intermittently every minute by means of currents from a commutator controlled by a master-clock at a central station, so as to move the armature first in one direction and afterwards in the other direction every minute. This system is in use in the 1st, 2nd, 3rd, 4th, 8th, 9th, and 10th arrondissements of Paris, and will shortly be extended to the left bank of the Seine. C. K. F.

562. *Electricity in Printing and Binding Works.* **W. H. Tapley.** (Cassier, 19. pp. 25–35, Nov., 1900.)—The power consumption in a printing office is reduced 40 per cent. by introducing electric driving, and the labour of handling is largely diminished. The first cost of electric driving is about £65 per press. The best motor is the "cumulative compound motor," controlled by armature resistance up to normal speed, and by the field control for higher speeds. The cumulative series winding provides a stiff starting torque. This is not necessary where the presses are constantly on long runs. The motors should have highest efficiency at 75 per cent. load, as this is their most frequent load. The cost of ungeared motors may be double the geared motor, but an advantage is obtained by their noiselessness, though it is a disadvantage that the motor armatures are not then interchangeable. The consumption of current on motors from 5 h.p. to 10 h.p. is the same whether the motors be geared or not; for smaller sizes the geared motor takes less power. The cost of upkeep of motor-driven machinery is less than when steam-driven, and this is diminished by circuit breakers which should always be used. No increased floor space should be taken by the motor, and the position of the controller must be studied for every new machine. The wiring should be in iron pipes, not only to protect the wires from mechanical injury, but from exposure to oil, printers' ink, and benzine. In binding, economy of power results from grouping sewing machines, wire stitchers, ruling machines, stabbing machines, folders, and case-making machines which require small motors from $\frac{1}{6}$ to 1 h.p. Nevertheless the increased output and minimised handling is worth the expense of individual driving. Heating the heads for embossing, stamping, glue, &c., by electricity has proved itself commercially superior to steam heating, with which the temperature cannot be controlled at all parts of the head. Any part of the head which is colder than another gives that part of the impression a lack of clearness. The heating of finishers' tools is more economically effected by gas. M. O'G.

563. *Electrical Heating of Metals.* **G. W. de Tunzelmann.** (Feilden, 3. pp. 387–400, Oct.; and 677–684, Dec., 1900.)—After giving some historical facts on this subject, and referring to Sir C. William Siemens' experiments in the early eighties, the author proceeds to enumerate more recent methods. Early attempts to use the arc struck between two carbons caused the deposition of a considerable quantity of carbon in the form of solid particles. In the fusion of iron and steel, this changes the character of the metal considerably, making it so hard that it is impossible to machine it afterwards; while in brazing and soldering it is difficult, and in some kinds of joints impossible,

on account of the deposition of soot, to get a clean joint. Methods introduced by the author for preventing this, led to "the Voltex process."

The method of applying electro-fusion to casting, and the causes of non-success are then discussed. The premature cooling of the upper surface of a steel casting, in the author's opinion, is the cause of faulty castings, and therefore any method which will keep the upper surface of the casting in a fluid state whilst the lower portion is solidifying, must produce sound castings free from both vacuous cavities and gas-bubbles. For this purpose the liquid metal surface is made to form the positive pole of an electric arc, of which a steel or carbon rod forms the negative pole. A mechanism is provided to raise and lower the rod forming the negative pole, so that the arc can be formed in the usual manner, and by moving the lid (shown in an illustration) the arc can be moved over the surface of the fluid metal. The object of this cover or lid is to prevent loss of heat by radiation. The thick iron walls of the mould have a thin metal prolongation lined with fire-brick, or similar resisting material; the fused metal does not stick to this, and since the fire-brick is an insulating material, no arc will be formed between the rod and the sides, and hence the latter will not be destroyed as might happen if no fire-brick were interposed. Experiments have shown that for the treatment of three blocks of crucible steel, each weighing about 6 tons, and one block of Martin steel of about 4 tons, a continuous current of 800 amperes at 60 to 70 volts is necessary. Calculations as to cost of production of steel by the above method show that Martin steel costs about 10 per cent. less and crucible steel 22 per cent. less than when made in the ordinary way.

Three processes in commercial use are then described in detail, namely, the Bernados process of electro-fusion, the Voltex process of electro-fusion welding, brazing, &c., and the Thomson process of electric welding. Data are given as to the amount of current used in these processes.

The author shows by calculations that the Voltex process of electric heating is far cheaper and more economical in many phases of manufacture and repairing than methods now in use. The disadvantages and difficulties of ordinary methods are claimed by the author to be in some cases partly, and in others entirely, obviated, by the new process. A case in point is in the brazing and filing up of a cycle frame, the cost of the old method by gas and coke being 5s. 9d., against 1s. 10½d. by the new one. The supposition that a great waste of current would be caused by passing the latter through a ring of metal, two ends of which are being welded together, does not hold good, as the long path of metal itself offers a greater resistance than the short path across the joint, and likewise the self-induction in the case of the alternating current causes only a small percentage of the current to take the longer path. According to the author, the larger apparatus used in the Voltex process might be employed by divers for cutting rapidly through large chain cables or iron plates under water, where the arc works perfectly well for this purpose, as it is not cooled down as much as might be expected by the water. The intense heat turns the water surrounding it into steam, so that the arc is insulated from the water by a cushion of vapour.

Very fine tools, taking carbons 7 mm. in diameter, are made for fine brazing and for jewellers' work, such as making the joints in rings. It should be of special value in working platinum, which melts readily or merely softens, according to the portion of the flame which is applied to it. Thus for many kinds of fine work, as applied to precious metals, it would be far more convenient than the methods at present in use. Similar instances of superiority

are given, and comparisons as to time taken, which in most cases show striking reductions.

The article is well illustrated by photographs. O. J. S.

564. *Pile-driving Machines.* **F. J. Rowan.** (Inst. Engin. and Shipbuilders, Trans. 43. 4. Feb. ; Discussion, 43. 5. March, 1900.)—After reviewing the various types of pile-driving engine which have been used, some of them from the earliest times, the author proceeds to sketch the attributes of the ideal pile-driving machine—lightness, speed of working, long range of fall, mobility, and cheapness. In an electrically driven machine designed by the author the weight is attached to a long, flat board, which is lifted vertically by the friction of two rollers, one on each side ; disengagement is effected by moving one roller, the spindle of which is carried by an eccentric bush. As soon as the weight has fallen the roller is moved back so as to again nip the board and hoisting proceeds at once at full speed. The rollers are driven by an electro-motor which runs continuously in one direction.

Discussion.—**C. C. Lindsay** remarked that the connection between the driving rollers and the weight, whether it was flat timber or iron, would, when at its greatest height, offer so much surface to the wind that it would be practically unmanageable. He referred to the ordinary machine in which the weight is raised by a small steam winch as a survival of the fittest. **A. S. Biggart** suggested that the substitution of an electro-motor for the steam winch might be the best mode of application of electricity to pile-driving. The author in reply stated that the principal object of the clutch described was to have the blows follow one another rapidly. H. R. C.

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565. *Electric Dock-cranes.* **L. J. Magee.** (Cassier, 18. pp. 267–281, Aug., 1900.)—A description of the electric cranes in various German harbours with illustrations (among others) of a solenoid brake and a double controller. In the latter the two motors for hoisting and slewing are controlled by one handle which actuates the two controllers through a universal joint ; the two operations are thus readily performed simultaneously, the load following the direction of movement of the handle. H. R. C.

566. *Electric Travelling Cranes.* **C. W. Hill.** (Elect. Rev. 47. pp. 367–368, Sept. 7, 1900.)—The author first sketches the development of the electric traveller, and then gives a description, with diagrams, of a recently designed travelling crane for a load of 30 tons with a hoisting speed of 4 feet per minute, cross traverse 100 feet per minute, and longitudinal traverse 400 or 200 feet per minute. H. R. C.

567. *The Practical Value of Science.* **J. Perry.** (Inst. Elect. Engin., Journ. 30. pp. 43–68, Dec., 1900.)—Presidential Address to the Institution of Electrical Engineers.

GENERATORS, MOTORS, AND TRANSFORMERS.

568. *Effect of Armature Current on the Wave-Form of an Alternator.* **F. G. Baum.** (Elect. World and Engineer, 36. p. 1002, Dec. 29, 1900.)—The effect of the armature current on the wave form of an alternator is deduced graphically from elementary considerations. The case of an alternator which gives a sine curve of p.d. on open circuit is considered. When a current almost in phase with the e.m.f. is passing through the armature, then it is shown that owing to the reaction of the magnetising force produced by the armature current, the shape of the wave is no longer a sine curve. As compared with a sine curve it is raised on the ascending side and lowered on the descending side. The effective value, however, of the volts remains the same. When the current lags by about 90°, then it tends to demagnetise the field in all positions of the armature. We now get a peaked wave and the effective value of the voltage is lowered. When the current is about 90° in advance of the e.m.f. then the shape of the wave is flattened and the effective voltage is increased. The armature current in this case tends to magnetise the field in all positions, and if this reaction is great we get a symmetrical wave, the ordinates of which attain two "maximum" values in the half period.

A. R.

569. *Transformation of Alternating into Direct Current.* **P. Janet.** (Écl. Électr. 24. pp. 294–297, Aug. 25, 1900. Paper read before the International Electrical Congress at Paris.)—The author compares the four systems of changing alternating into direct currents. (1) *Electrolytic Rectifiers.* These depend on the property of aluminium electrodes, which allow no current to pass when forming the positive electrode in a cell; in an acid solution they will withstand a pressure of 20 volts, and in an alkaline solution of 140 volts, without letting current pass. Up to the present no practical use has been made of this property. (2) *Rectifiers*, consisting of an ordinary commutator driven by a synchronous motor. With large currents the sparking becomes prohibitive, and their extended use is not probable. (3) *Rotary converters* consisting of a synchronous motor and direct-current dynamo, combined to form one machine with a single armature-winding. There is saving of material over two machines, not only in the saving of one set of field magnets, but also in the copper on the armature. Comparing the output of a machine used as a direct-current dynamo and as a converter, the advantage is slightly with the former when the alternate current is single-phase, but the output as converter increases with the number of phases, and with six-phase currents is about double the output when used as a dynamo. The efficiency of a converter is greater than that of a motor-generator, but, as it cannot be run directly off a high-tension circuit, the efficiency of the reducing transformer must in general be allowed for. (4) *Transformer-commutators.* These consist of a static transformer transforming a current of a small number of phases into one of many phases, and an ordinary commutator, which adds up the e.m.f.'s. of the different phases, as in a dynamo. To avoid sparking, the number of commutor sections, and consequently the number of phases, must

be large; this entails either a large number of collecting rings on the commutator shaft, or revolving brushes with a fixed commutator. This system presents economy in material over a rotary converter, as a transformer is generally necessary in either case. Its efficiency also is high, as only a very small synchronous motor is required to turn the commutator. G. H. B.

570. *Design of Motors and other Apparatus for Intermittent Loads.* **E. Oelschläger.** (Elektrotechn. Zeitschr. 21. pp. 1058–1063, Dec. 20, 1900.)—Lifts may be taken as a type of electrical apparatus in which the load is intermittently applied for short periods. If a given maximum rise of temperature is desired under working conditions, it is not in general necessary to so design the motor that it would only attain this rise of temperature if worked continuously. Among other cases considered by the author, he takes the case of a resistance that would have a given rise of temperature if absorbing continuously 1 kw. His calculations show that if this same resistance were to absorb 8 kw. for half a minute, and were then switched off for five minutes, and this process were repeated indefinitely, its temperature would never at any time rise above that which it reached in the former case. The problem is dealt with both from the graphical and analytical points of view. The simplest case is that of the design of a resistance. The graphical method depends in the main on the preliminary construction of two curves, the one showing the rate at which the temperature increases under a given load, and the second the rate at which the temperature decreases when the load is thrown off. Supposing, then, that it is known how long the load is left on and how long it is thrown off, it is a simple matter to determine graphically the highest temperature reached, seeing that after the load has been switched on and off a few times the temperature goes through a well-defined cycle of variation. The designer would have to construct a variety of curves on the above lines, showing the rates at which wires of different gauges increased in temperature under various loads.

The analytical method depends on the determination, either by experiment or by calculation, of a quantity which the author calls the time-constant. The increase of temperature in a resistance follows a logarithmic law, and the time-constant may be defined as the time after which the rise of temperature is 0·633 times the maximum rise that is reached in the steady condition. It is therefore closely analogous to the time-constant in an inductive circuit. In considering the case of intermittent loads the author finally arrives at the equation—

$$\frac{a}{\mathrm{P}} = \frac{1}{1 - \frac{\mathrm{T}}{a}\log\left\{p - e^{\frac{a}{\mathrm{T}}}(p-1)\right\}},$$

where a is the length of period of loading, P is the length of the period of loading plus the period of rest, T is the time-constant, and p is the ratio of the permissible overload to the load which could be taken continuously. Various simplifications of this equation under certain conditions are considered. In particular, it will be noticed that the equation becomes $p = \mathrm{P}/a$ if the ratio of a to T is small. In order to apply the equation it is necessary to know the value of T. The author shows how to calculate its value, and adds that Siemens and Halske have also experimentally ascertained it in various cases, the observations agreeing reasonably well with the calculations. The experiments gave the following values for the time-constant in the following cases,

,iz., for a 300-kw. transformer, 3·9 hours; for a polyphase motor of 35 h.p., d·9 hours; for an enclosed direct-current generator of 9 kw., 6·5 hours; for a irect-current generator of 68 kw., 3 1 hours; for a resistance absorbing 2 kw., n0 minutes. In all these cases, supposing a to be 1 minute and P to be i minutes, then p becomes 3—*i.e.*, the permissible overload is three times the oad that could be taken continuously. W. H. S.

571. *Theory of Synchronous Motor.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 18. pp. 611–612, Dec. 16, 1900.)—As a result of the recent iscussion on the theory of the general alternating-current transformer [see bstract No. 266 (1901)], the author is led to introduce a modification nto his treatment of the problem of a synchronous motor [Abstract No. 247 1901)]. The modification consists in substituting v_1 (the armature leakage oefficient) for v_2 (the field coefficient) in the formulæ developed by the uthor. A. H.

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572. *Designs for Small Single-phase Induction Motors.* **J. C. Brocksmith.** (Amer. Electn. 12. pp. 486–489, Oct.; 534–535, Nov.; and 572–574, Dec., 1900.)—Designs and working drawings are here given for the construction of small motors, respectively of ½ h.p., 1 h.p., and 2 h.p., working on 50 or 100 volts and 125 and 0 ∼. The motors are designed to be started by a phase splitting device. E. K. S.

573. *Requisites of Lighting Generator Sets.* **H. G. Reist.** (Elect. World and Engineer, 36. pp. 916–917, Dec. 15, 1900. Paper read before the U.S. Engine Builders' Association, Dec. 4, 1900.)—The author gives a table of suggested standard speeds of engines according to the power of generator, and discusses the effect of variations in speed when running alternators in parallel. H. R. C.

574. *General Alternating-Current Transformer.* **G. Ossanna, J. Heubach, B. A. Behrend, H. Grob,** and **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 1031–1033, Dec. 6; 1089–1090, Dec. 27, 1900; and 22. pp. 86–91, Jan. 24, 1901.)—Some further correspondence on this subject [see Abstracts Nos. 264, 265, 266 (1901)]. A. H.

575. *600-H.P. Induction Motor.* (Elektrotechn. Zeitschr. 21. pp. 1087–1088, Dec. 27, 1900.)—A description of a 600-h.p. induction motor, running at 75 r.p.m. and a frequency of 22·5. The motor was constructed by the Maschinenfabrik Oerlikon, and is used for driving a pump in a German mine. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

576. *Alternators in Series for the Transmission of Power.* **M. Leblanc.** (Écl. Électr. 25. pp. 268–270, Nov. 17, 1900. Paper read before the International Electrical Congress at Paris.)—It is proposed to run induction machines as generators and to make use of the property they possess of running equally well in series as in parallel. The system suggested is analogous to that designed by Thury at Genoa, but the author will use alternating instead of direct current. The alternators will be compounded so that they will give a practically constant current at all loads. On short circuit the armature reaction will be so great that the current cannot exceed 10 amperes; hence there will be no risk from this cause. He proposes to adopt the exceedingly low frequency of eight periods per second. The advantages of this low frequency are numerous. The impedance of the line is very small, and there is practically no Kelvin effect. The dangers from resonance and the difficulties of insulation are very considerably lessened. Motors act also exceedingly well at low frequencies. At the receiving end of the line he will use his induction motors, which can have a power factor of unity. The lowering of the frequency gets rid of all the disadvantages of alternating currents whilst retaining all the advantages, such as the getting rid of commutators and saving the necessity of regulating both the generators and the motors. A. R.

577. *Condensers in Alternate-current Circuits.* **P. Boucherot.** (Écl. Électr. 24. pp. 297–302, Aug. 25, 1900. Paper read before the International Electrical Congress at Paris. Abstract in the Electrician, October 12, 1900.)—The author reviews shortly the various uses to which a condenser may be put in alternate-current work, especially in the case where a self-induction is connected in series and adjusted to resonance. A condenser may be connected in series with an inductive circuit to allow the passage of a larger current. It may be connected in shunt to diminish, as far as the generator is concerned, the magnetising currents of transformers and motors.

It may be used to obtain a constant current from a source of constant e.m.f. in either of the following ways:—(1) Connect a condenser and self-induction, adjusted to resonance, across the mains of constant e.m.f.; a circuit in shunt on the condenser or on the self-induction will have a constant current. (2) Connect two condensers and two self-inductions alternately in the four arms of a quadrilateral; if one diagonal be connected to constant e.m.f. mains, a circuit connected to the other diagonal will have constant current. Alternators may be excited off a condenser connected in series with a self-induction adjusted to resonance, so as to behave like a shunt-wound or series-wound direct-current dynamo, according as the condenser and self-induction are connected in series with, or in shunt to, the alternator, or the two connections may be combined to produce a compound excitation. The objections to the use of condensers are their high cost and their liability to produce very high potential differences on breaking the circuit. The author, however, considers that when a certain capacity is reached this effect will diminish. G. H. B.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

578. *Ringsend Power Station, Dublin.* **A. C. Shaw.** (Street Rly. Journ. 16. pp. 345–355, May, 1900.)—This article contains a very full description of the main power station of the Dublin United Tramway Company. The boiler-house is 76 feet by 131 feet, and contains 12 Babcock boilers, each having a heating surface of 2,530 square feet, fired by Vicars stokers. The top central portion of the boiler-house consists of a large bunker, capable of holding 500 tons of coal, the bunker being provided with chutes, which project down in front of the different boilers. The coal-handling machinery is described in some detail, and was provided by the C. W. Hunt Company, of New York. The coal is taken out of the barges by a steam-driven grab, having a capacity of about 1½ tons; it is then deposited in a hopper, from which it is emptied into skips, which convey it to a large storage shed at the back of the boiler-house. It is finally taken by a form of bucket conveyer to the bunker above mentioned, which is placed above the boilers. The chimneys are of steel, and are two in number. They are lined with fire-brick, and have a height of 200 feet, and a diameter inside the brick lining of 10 feet. Each chimney is built of steel plates, tapering upwards and finishing with an ornamental cap at the top. The shell plates are lap-jointed and riveted, and vary from ⅜ inch to ¾ inch in thickness. The constructional details of the chimney are fully described. An economiser of 384 tubes has been installed. The engine-room, which is 153 feet by 80 feet, contains five Corliss engines by the Allis Company, each of which is direct coupled to a 500-kw. generator. They run at 80 r.p.m.; the cylinders are 20 inches and 40 inches in diameter, and the stroke is 48 inches; the crankshaft journals are 33 inches long; the flywheel is 19 feet in diameter, and weighs rather more than 30 tons. There are four negative boosters, giving outputs varying from 15 kw. to 24 kw. at 30 volts; they are motor-driven, and the voltage on the generator terminals is varied by means of a resistance connected in shunt with the series field. The travelling crane is designed for a load of 25 tons, with a lift of 26 feet; it is operated by three motors, series-wound, the motor for hoisting being rated at 20 h.p. The condensing plant consists of three Wheeler surface condensers, each having 3,400 square feet of heating surface. All the cables were supplied by the National Conduit and Cable Company, of New York. There are 18 feeders in all, varying from 0·2 square inch up to 0·75 square inch; the shortest is about 5,200 yards long, and the longest 3,490 yards. The cables are laid in wrought-iron pipes of an internal diameter of 3 inches. The manholes are about 450 feet apart, and vary in size according to the number of pipes leading into them, the largest being 10 feet square and 6 ft. 6 in. deep. There are also four return feeders, one composed of three cables, each having a sectional area of 0·538 square inch, and the other three consisting of two cables of 0·538 square inch. The article concludes with a brief description of the outside work on the track and overhead equipment. W. H. S.

579. *Electricity Works at Chèvres (Geneva).* (Elect. Rev. 47. pp. 586–591, Oct. 12; 665–668, Oct. 26; 708–709, Nov. 2; 772–773, Nov. 16; and pp. 912–913, Dec. 7, 1900.)—These articles deal with an important example of electrical distribution in the Canton of Geneva utilising the power of the river Rhône. The history of the hydraulic works is first detailed. The site of the new generating works is 600 m. up the river, and opposite the Chèvres Mill. In 1893 3,000,000 francs were voted by the Corporation for the first portion of the works, which was to include (1) the construction of the dividing dyke, the

coffer dams on the left shore, and the dam ; (2) the construction of the coffer dam on the right shore, the turbine buildings, and the head and tail races ; (3) erection of the machinery and the laying of the feeders. The dam consists of one inverted arch foundation, two abutment piers, five intermediate piers having between them spaces for six gates with an opening of 10 m. The draining, which lasted nearly a year, was done by a Dumont pump and a pulsometer. The turbine building is 137 m. long, in which, during the year 1895, the first three sets of generators and two sets of exciters were installed. The generator sets each have a minimum output of 1,000 h.p., and comprise double turbine and alternator mounted on the same shaft. The exciter sets are similar, their output, however, being only 150 h.p. each.

According to the height of the river, the turbines had to work on the following conditions :—(1) In winter with a fall of 8·5 m. they had to work with an output of 1,200 h.p. with a volume of water as small as possible, yet at the maximum efficiency. (2) In summer with high water and using a net fall of 4·3 m. they were required to give 800 h.p. with an optional volume of water, and an efficiency of only 50 per cent. (3) To always maintain a speed of 80 r.p.m., without too large or too costly machinery. The scheme of Escher, Wyss & Co., of turbines arranged as stated above, was accepted. The shaft of massive steel 0·3 m. diameter is firmly supported by four bearings, and coupled direct to the alternator shaft, at the upper end of which is a ring bearing specially constructed for forced lubrication. Hydraulic regulating apparatus was adopted which was very effective ; for example, with a sudden variation of a load of 300 h.p. the speed was only reduced momentarily by 3 per cent., and when the full load was thrown off the variation was from 3 to 5 per cent., and in 4 to 5 seconds the governor had established normal speed. A description of the turbines, strainers, and admission gates is given. There are fifteen dynamos—Nos. 1–5 and 12–15—by the Compagnie de l'Industrie Électrique, Geneva, and Nos. 6–11 by Messrs. Brown Boveri & Co. Fourteen of the machines are two-phase alternators and the fifteenth is for direct current.

Machines 1–5, of 1,200 h.p., are of the Thury unipolar inductor type which have been designed of great strength, and with moderate self-induction. They are capable of being short-circuited without damage, and they run easily in parallel. The vertical shaft arrangement facilitates the repair of the machines, and the method of insulating the stationary armature and field magnets enables the insulation to be made very perfect. These alternators are 4·5 m. diameter and 2·2 m. high. The moving part is formed by a cover of cast steel, which consists of a double tooth crown, each with 34 radially placed teeth. The field magnet winding is formed of ribbon of copper insulated by rubber-treated canvas ; the armature winding consists of 34 bobbins of insulated cable. The machines will give either single or two-phase currents, the two systems of field magnets and armatures being arranged in such a manner that they can be easily displaced with respect to each other : the voltage is 2,750 at 45 $\sim$. The electrical efficiency is 93 per cent. at full load. The total weight is 70 tons (French). The moving part on the shaft weighs 12 tons, the weight of the two turbines and their shaft is 12·05 tons, and the vertical pressure of water is 12 tons, so that the bearings of the dynamos have to support the load of 36·05 tons. This heavy weight has necessitated a special lubricated bearing.

Machines 6–11.—These are of a similar output to the previous ones, and the same periodicity, and are arranged to give 5,500 volts or 2,750 volts by the use of two independent windings which can be arranged in series or parallel.

ne machines are of the "umbrella" type, with fixed armature, tunnel wound. he magnet, of umbrella shape, carries 46 pole-pieces and the exciting bbins.

Machines 12–14.—These are, as before, of 1,200 h.p., but with a speed of 120 .m. They supply two-phase current at 5,000 volts with 46 ∼ . The mature is fixed and the field movable.

Machine 15.—This machine supplies continuous current for the electro-emical work of the Société la Volta at Chèvres. It is of the Thury type, and ves 4,000 amperes at 208 volts.

Switchboard.—There are small boards for each generator and one large neral board for distribution. The board is 26 m. long with 34 panels. The gh-tension parts are out of reach or behind the board. The high-tension witches are placed at the top of their respective panels, and are worked from distance by means of a chain and toothed wheel. The chain works a second heel keyed to a spindle which carries eight insulated contacts, which engage ght copper jaws; by this means eight breaks can be made, two in each con-uctor. The jaws are separated by thick slabs of slate. The fuses are behind e board in thick porcelain tubes which may be used as circuit breakers. he requirements of the system have rendered necessary the adoption of 2,750 olts for the underground lines, and 5,500 volts for overhead conductors.

Feeders (Underground).—From Chèvres to Geneva the distance is 5,825 m., nd is divided into five sections, the ends being brought to substations. The ethod adopted is due to Graizier, chief electrical engineer. A concrete ough is used in which the four conductors are buried in "bitumen-concrete" nd kept at a fixed distance of 0·5 m. from each other by special bricks. itumen-concrete is a mixture of bitumen, produced by the distillation of oil eated to 200° C., and small gravel well dried. In order to make it more astic a certain proportion of vaseline is added. The concrete was run hilst hot into the trough immediately after the laying of the conductors. he whole is covered with a layer of concrete and with a cover of cement. ach conductor comprises seven copper cables, each of seven strands, of 6 mm. diameter. At the substations are the necessary transformers and witchboards. It was found that, in spite of precautions, occasionally foreign atter or water got into the bitumen, and this necessitated some repairs. At e end of 1899 the total length of feeders underground and overhead is ,443 m., and the output 28,066,483 B.T.U. The principal users are the rbide and chemical manufacturers, various works, the tramways, and the ghting of the town and of many communes; also the waterworks, where a mp is in use capable of raising 380 litres per second 140 metres, coupled to a 1,000-h.p. two-phase motor.

Tramways and Lighting.—The tramway system and part of the lighting is pplied by continuous currents, the alternating current being transformed by lioth rotary converters. There are two converters for *lighting*, with a pacity of 100 kw. They have two independent windings and two com-utators to supply the three-wire system, and four slip-rings for the two-phase de. Armatures are slotted and of Gramme type. The field magnets are of ist steel with 14 poles. The weight of each machine is 6,750 kg. Each ommutator supplies 450 amperes at 110 volts running at 385 r.p.m. Trans-rmers of 50 kw. per phase supply the converters at 70 volts. For excitation, 00 watts are necessary. The efficiency of machines is 90 per cent. For the *amways* three 150-kw. converters are used. These have one commutator nd four slip-rings. The armatures are of drum type, and give 560 volts and 38 amperes at 336 r.p.m. They are supplied by 80-kw. transformers at 360

volts. The frame is of cast iron, and the pole-pieces of cast steel. There are 16 poles. The total weight of each machine is 11,600 kg. The number of watts required for excitation is 1,150, and the efficiency 90 per cent. For starting the converters, the liquid resistances at first supplied have been replaced by 5-kw. regulating transformers in parallel with the secondaries of the main transformers.

Cost of Works.—This has amounted to £383,905, which includes £150,000 for turbines and dynamos, and £95,000 for feeders, transformers, and sub-stations.

A publication has been issued under the editorship of Turretini, minutely descriptive of this great undertaking. W. W. H. G.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

580. *Electric Haulage at the Eureka Mines, Windber, Penn.* **A. S. M'Allister.** (Amer. Electn. 12. pp. 317–321, July, 1900.)—This is an illustrated account of electric plant installed for the Eureka coal mines. Electric power is used for haulage by underground locomotives, compressed air being used for pumping and coal cutting. G.E. and Thompson-Ryan generators are used in parallel. Owing to the greater resistance of the series coils of the latter, the usual balancing wire connected inside the compound coils is in this case connected inside the compound coil of the G.E. machine and to a point part way along the series-winding of the Thompson-Ryan machine. This is stated to give good results. The method of controlling the motors (series-parallel) seems to be inapplicable for the work, and the troubles arising and suggestions for obviating are described. Ll. B. A.

581. *Electrolysis by Earth Returns at Peoria.* **A. B. Herrick.** (Street Rly. Journ. 16. pp. 996–1000, Dec., 1900.)—The author disputes the conclusions of D. H. Maury in his paper before the American Waterworks Association [see Abstract No. 2518 (1900)] that the bursting of the standpipe at Peoria was due to electrolytic corrosion. He contends that the material was inferior, and that many instances of similar "pitting" of cast iron, wrought iron, and steel structures were on record before electric traction was known. E. H. C.-H.

582. *Electric Conduit Railways.* **F. G. Cudworth.** (Street Rly. Journ. 16. pp. 1026–1029, Dec., 1900. Paper read before the Brooklyn Engineers' Club, Oct. 11, 1900.)—After reviewing the development of electric conduit systems from 1884 to 1900, the method of construction adopted in New York City is given in outline. In 1900 the Metropolitan Company of New York adopted the Falk cast-weld joint for repairing old 7-inch girder rails on the Lexington Avenue cable line, with the result that there was great improvement in the case of riding. The cost of the cast joint was $4·25, including cleaning the rail with sand-blast and furnishing all necessary materials. The cost of excavating and relaying pavement around the joint was about $2·70, so that the total cost of the joint was little more than half the cost of new rails.

It is difficult to give an exact estimate of cost of underground con-

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

it construction, but in New York City, where many pipes had to be moved and much repairing done, the cost per mile of single track was about $90,000, including feeders; in some cases it reached $150,000, and special work is enormously expensive. One double cross-over and two double-track turn-outs at 34th Street and East River cost $95,334.

E. H. C.-H.

583. *Economy of Welded Joints.* **K. Beyer.** (Street Rly. Journ. 16. pp. 1-16-1017, Dec., 1900.)—Experiments on an important German tramway show that after six years' use the wear at the joint is on the average twice as great as on any point on the rail. Electric welding in the United States is dependent on the company controlling the patents, and enormously large apparatus is required. In the Goldschmidt method aluminium is used to secure high temperatures; and as but little apparatus is required, the cost per joint is lower. Calculations are given from which the author concludes that, taking all things into consideration, the welded joint is 20 per cent. more efficient than the fish-plate joint. E. H. C.-H.

584. *Contact Rails on the Manhattan Elevated Railway.* (Street Rly. Rev. 10. p. 708, Dec., 1900.)—Drawings are given of the contact rails, joints, and insulators which are being installed on this railway. The rails are 6 inches high, of T-section, weighing 100 lbs. per yard, and contain carbon 0·073 per cent., manganese 0·340 per cent., sulphur 0·073 per cent., phosphorus 0·069 per cent. The rails are each 60 feet long, and are erected in sections of 300 feet; they are anchored at the middle, but free to slide in insulator clips elsewhere. The insulator blocks are of artificial granite, placed every 9 feet. The joints between the 60-feet rails in each section are made with two-bolt fish-plates and four solid copper bonds, hydraulically riveted into $\frac{7}{8}$-inch holes, two in the web under the fish-plates and two in the bottom flanges. Each bond has a sectional area of 0·344 square inch. The 300-feet sections are joined by fish-plates having a slot at one end, and by four 18-inch, curved, stranded copper bonds, with rope-laid strands of wire not larger than No. 4 B & S, the sectional area of each bond being 0·353 square inch. All these bonds are riveted in the bottom flanges. The distance between the 300-feet sections to allow for expansion is determined from a table: if the rail is laid at 0° F., the gap is 3 inches, at 60° it is $1\frac{1}{2}$ inches, and at 120° it is nothing.

E. H. C.-H.

585. *Double-truck Cars.* **N. H. Heft.** (Street Rly. Rev. 10. pp. 650-651; discussion, pp. 651-656, Nov., 1900. Paper read before the Amer. Street Ry. Assoc., Kansas, Oct., 1900.)—Cars cannot be constructed and equipped so as to operate with equal economy under all the varying conditions of different tramway systems. Tramway trucks have hitherto been constructed on the lines of single-horse trucks. The author considers that steam railway lines should rather be followed. After experience with heavy and light motors, mounted with two motors on one truck, the other truck being an idle or trail truck, as well as with one motor on each truck, the author has found that, while greater efficiency is shown with the latter method, the two motors mounted on one truck show a saving in labour, first cost of the trail truck, and cost of maintenance. Maximum efficiency, with minimum cost of maintenance, with both heavy and light motors, has been obtained by mounting two motors on each truck, making a four-motor equipment. With

this form of equipment, higher speed and quicker acceleration are obtained with lower power consumption, both in the average and total for the whole trip. Controllers have not developed as rapidly as motors. The four-motor controllers in their present form are cumbersome, and it is more satisfactory to use a small pilot controller on the platform with some developed form of main controller underneath the car body. The author's double-truck car on the lines of steam railway trucks has weights as follows: Trucks, 3,970 lbs. each, four motors 2,385 lbs. each, car body and equipment, 12,300 lbs.; a total weight of 29,780 lbs. This amount divided by 63 passengers gives a dead weight of 473 lbs. per passenger. The cars of to-day show a dead weight of 750 lbs. to 1,100 lbs. per passenger.

Discussion.—Great difference of opinion was expressed amongst the speakers as to the economy of power with four-motor equipments, but all agreed that the absence of slipping wheels, the quicker acceleration and the consequent higher schedule-speed compensate for the increase (if any) in power consumed; also that it is considerably cheaper to maintain four motors under a car than it is to maintain two motors under the same car, and this difference in cost of maintenance more than offsets the interest on the extra capital cost. E. H. C.-H.

586. *Competitive Tests of Street Car Brakes.* (Street Rly. Rev. 10. pp. 462–464, Aug., 1900.)—In 1899 the Board of Railroad Commissioners of New York invited makers to submit their brakes for competitive tests, which were made with the utmost care with special instruments for graphically recording the speed and distance traversed. Tests were made only when the rails were dry, and all on 2,750 feet of street, having a total fall of 8·8 feet. Tests were made without sand at 8, 12, 15, and 16 m.p.h., and also with sand at 16 m.p.h. The results are shown in Tables I. and II.

TABLE I.

SHOWING AVERAGE STOPS MADE WITH ALL BRAKES TESTED AT 8, 12, 15 AND 16 MILES PER HOUR, AND AT 16 MILES PER HOUR WITH SAND.

NAME OF BRAKE.	8 MILES PER HOUR.		12 MILES PER HOUR.		15 MILES PER HOUR.		16 MILES PER HOUR.		16 MILES PER HOUR, WITH SAND.	
	Feet.	Secs.	Feet.	Secs.	Feet.	Secs.	Feet.	Secs.	Feet.	Secs.
Peckham Motor, Truck and Wheel Company	42·41	7·03	59·52	6·44	70·50	6·87	81·25	7·43	79·91	7·51
Devlin Street Car Brake Co.	54·08	7·38	65·80	8·86	92·36	9·58	93·63	9·51	84·91	7·98
Christensen Air Brake Co.	56·86	6·20	88·25	7·88	113·80	8·60	130·75	9·74	93·70	6·63
Standard Air Brake Company	54·19	5·79	76·08	5·48	86·83	7·32	104·47	8·48	93·04	6·58
General Electric Company	45·00	5·34	111·02	8·95	114·86	8·32	134·72	8·62	116·66	6·58
Columbia Car Light & Brake Co.	65·86	6·16	99·94	5·46	139·50	7·30	155·08	7·70	203·66	7·55
Sauvage Street Car Brake Co.	46·11	4·00	78·58	5·67	129·16	8·50	138·27	8·60	143·25	7·31
J. G. Brill Company	35·11	3·16	67.83	6·12	121·88	7·50	108·44	6·22	127·16	7·47
Safety Appliance Company	40·27	3·15	68·86	4·54	135·11	5·92	140·69	6·07	†	†
Vogel Brake Company	50·86	7·56	72·83	7·86	92·11	9·62	119·94	10·56	106·58	9·35
G. P. Magann Air Brake Co.	42·72	6·75	56·80	7·33	81·80	9·12	95·66	9·17	89·16	8·70
Price-Darling Company	45·27	7·23	—	—	—	—	—	—	—	—
Sterling Supply & Manufg. Co.	41·50	6·99	57·00	7·91	75·27	9·59	81·41	9·35	90·66	9·45
Electric Selector and Signal Co.	38·75	7·71	50·00	7·95	60·02	8·28	72·33	9·35	73·08	8·92
Bach & Schlegel	—	—	—	—	—	—	—	—	—	—
I. E. Reyburn	66·80	7·17	94·00	8·55	—	—	—	—	—	—

TABLE II.

OWING STANDING OF BRAKES BASED ON THE FORMULA AND PER CENT. OF RATING BASED ON THE AVERAGE STOPS, ALSO PER CENT. DEDUCTED FROM THIS STANDING FOR SKIDDING OF WHEELS AND THE PER CENT. OF RATING AFTER MAKING THIS DEDUCTION.

NAME OF COMPANY.	Formula * $\frac{w\ s^2}{d}$	Average stop at all speeds, Feet.	Per cent. of rating based on average stop.	Per cent. deducted for skidding of wheels.	Per cent. of rating after deduction.
ectric Selector and Signal Co....	66,197	58·83	100·00	1·7375	98·26
rling Supply & Manufacturing Company	58,073	69·16	87·73	0·875	86·86
ckham Motor, Truck and Wheel Company	64,410	66·71	97·30	10·70	86·60
P. Magann Air Brake Company	54,853	73·22	82·86	4·00	78·86
vlin Street Car Brake Company	54,424	78·15	82·21	6·20	76·01
ndard Air Brake Company.....	49,907	82·92	75·39	5·75	69·64
neral Electric Company	45,630	104·45	68·93	0·225	68·71
gel Brake Company	44,300	88·46	66·92	0·875	66·05
ristensen Air Brake Company...	44,322	96·67	66·95	2·00	64·95
G. Brill Brake Company	44,545	92·08	67·29	4·35	62·94
ety Appliance Company	38,290	96·10	57·84	1·0625	56·78
vage Brake Company	36,600	107·07	55.29	0·6875	54·60
ce, Darling & Company	31,803	45·27	48·04	0·1875	47·85
G. Reyburn Brake	29,547	80·40	44·68	0·25	44·38
lumbia Car, Light & Brake Co.	29,325	132·80	44·30	0·225	44·08
ch & Schlegel (no test).....	—	—	—	—	—

Per cent. deducted for skidding wheels is based on the following values :—

Skidding 15 feet or more.		Skidding 10 feet to 15 feet.		Skidding 5 feet to 10 feet.	
e large wheel	0·25	One large wheel	0·125	One large wheel	0·0625
e small wheel	0·125	One small wheel	0·0625	One small wheel	0·05125
rge and small wheels	0·45	Large and small wheels	0·225	Large and small wheels	0·1125
wheels	1·00	All wheels	0·75	All wheels	0·50

Tests were also made with one type of brake on a wet rail, the average p being 71·7 feet as against 60 feet on a dry rail. After adding or ducting points of merit or demerit for the following features : Reliability l simplicity of system ; liability of brakes to act when they should not ; e of operation by ordinary motormen ; cost of equipment and maintance ;—the order of merit was :—(i) Electric Selector and Signal Co. Peckham Truck Co. (iii) Sterling Electric Co. (iv) Magann Air Brake (v) M. H. Vogel. (vi) Devlin Street Car Co. (vii) J. G. Brill & Co.

* w = Number of passengers × 140 + weight of car 20,816 pounds, except the General ctric car, which weighed 24,000 pounds.
s^2 = The average initial speed squared.
d = The average stop at all speeds

(viii) Sauvage Street Car Brake Co. (ix) Standard Air Brake Co. (x) Christensen Engineering Co. (xi) General Electric Co. (xii) J. E. Reyburn. (xiii) Columbia Car and Brake Co. (xiv) Price, Darling & Co. (xv) Safety Appliance Co. (xvi) Bach & Schlegel. E. H. C.-H.

587. *Solution of the Electric Vehicle Problem.* **Luxenberg.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 360–364, Nov. 1; and 380–385, Nov. 15, 1900.)—A previous writer in this paper has shown that the only practical methods of making electric vehicles more economical were (i) by reducing the weight of the vehicle itself by careful construction and choice of materials; (ii) by reducing bearing friction by use of roller bearings; (iii) by reducing the resistance due to rolling friction at the wheel rims by increasing the wheel diameters. The author enlarges on these points. A possible saving of 4 per cent. of the total weight of the vehicle and 4 per cent. in power is all that can be effected by the first method. By roller bearings the total weight may perhaps be reduced by 6 per cent., as the power required is 16 per cent. less. The third method is the only one which promises any great improvement. The coefficient of resistance of the rolling friction of the wheels against the ground is given by the formula $\tan \alpha = f/r$, where f = the coefficient of the rolling friction dependent on the nature of the surface, r = radius of the wheels, α = angle of slope on which the car keeps up constant speed without power, or without brakes on. If K = tractive force on the vehicle, whose weight is G = mg, then—

$$K = G.\tan \alpha = G\frac{f}{r} = m.\frac{f}{r}.g,$$

and since (force × distance) = work, the work done is—

$$A = \frac{G.f.L}{r} = \frac{m.f.L.g}{r}, \text{ where } L = \text{distance.}$$

Thus K and A are inversely proportional to the wheel's radius; or we may state that the energy required to move a wheel round through a given angle is independent of the size of wheel, or that the work required for one revolution is independent of the size of the wheel. The same law holds for friction in bearings, because the larger the wheel the fewer the revolutions required to cover a given distance. For the same weight, and for the same distance on the level, tractive force, and energy required, are inversely proportional to the wheel radii; the distances covered with the same expenditure of energy are directly as the wheel radii.

The effect of increasing the wheel diameter and thereby proportionately lessening the coefficient of resistance is then considered. An electrical vehicle with wheels 100 cm. in diameter has a resistance on average roads of 3 per cent. of its complete weight. Allowing for the losses between the accumulators and the wheels, the work required per ton-kilometer is $\frac{3}{100}.1000.1000$ kgm.-meters = 82 watt-hours. Hence, with a 44-cell battery, giving 82 volts, one ampere-hour per ton-km. would be required.

If the car has to go 80 km. with one charge at 16 km. per hour, then the discharge must be 80 ampere-hours for 5 hours per ton of total weight. Such a Planté battery weighs not more than 500 kg., *i.e.*, half the weight of the loaded car. If g' = weight of loaded car, exclusive of battery, g'' = the weight of battery, G = $g' + g''$, D = mean wheel diameter in cm.

α = the coefficient of resistance expressed as a percentage of the weight, en—

$$\frac{g''}{G} = \frac{g''}{g' + g''} = \frac{50}{D}$$

ience—

$$g'' = g' \frac{50}{D - 50} \qquad (a)$$

t—

$$G = g' + g''$$

$$\therefore G = g' \frac{D}{D - 50} \qquad (b)$$

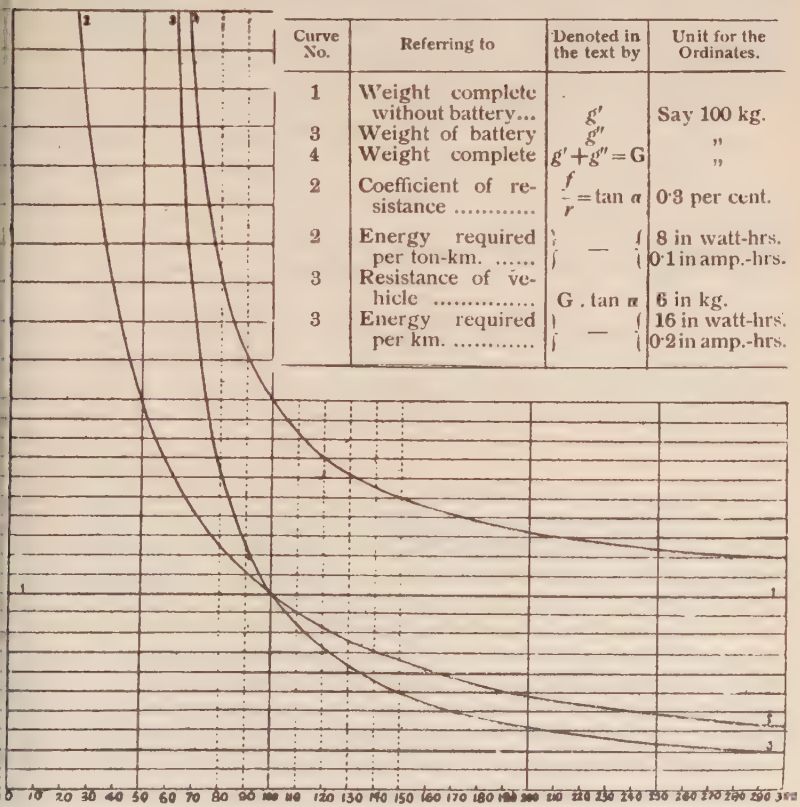
d—

$$\tan \alpha = \frac{300}{D}$$

$$\therefore G \cdot \tan \alpha = g' \frac{300}{D - 50}$$

equations (a) and (b), since g' is independent of the size of wheel, the only riable factor in equations (a) and (b) is $1/(D - 50)$. We can thus plot the

Curve No.	Referring to	Denoted in the text by	Unit for the Ordinates.
1	Weight complete without battery...	g'	Say 100 kg.
3	Weight of battery	g''	"
4	Weight complete	$g' + g'' = G$	"
2	Coefficient of resistance	$\frac{f}{r} = \tan \alpha$	0·3 per cent.
2	Energy required per ton-km.	—	8 in watt-hrs. 0·1 in amp.-hrs.
3	Resistance of vehicle	$G \cdot \tan \alpha$	6 in kg.
3	Energy required per km.	—	16 in watt-hrs. 0·2 in amp.-hrs.



(Mean diameter of the wheels in cm.)

rve in the adjoining Figure, which clearly shows the influence of the size of heels on the weight and energy required, the vehicle being supposed to weigh 00 kg. without battery, and apparently to go 80 km. with one charge. With

50 cm. wheels, 80 km. is impracticable. By decreasing the wheels 20 per cent. from 100 cm. diameter (carriage size) to 80 cm. (pony size), the size and output of the battery, and therefore its maintenance, increase by 63·6 per cent. By increasing from carriage size to freight-waggon size (120 cm.), a corresponding decrease of 29 per cent. is made; or if to omnibus-back-wheel size (150 cm.), the decrease is 50 per cent.

In snowy weather the resistance rises to perhaps four-thirds of the normal. It is best to choose batteries for a normal four- or five-hour performance, *i.e.*, for 60 to 80 km., and having the highest possible capacity and shortest possible charging-time. Small capacity and light battery with a long charging-time should be avoided. Experience in America, London, and Paris confirms this.

Difficulties in construction arise if the steering wheels are large. To make room for the wheels the battery must be moved back, and this tends to make the car unmanageable on slippery roads, unless it is made longer and broader. Experience has shown that, to prevent the car rotating about a vertical axis through its centre of gravity on curves, at 16 km. per hour, the wheel base must not exceed four-thirds of the width between wheels. Since 150 cm. is usually the limiting width, the longest wheel base possible is 200 cm. With an 80-km. Planté battery, the author has found the following wheel diameters permissible :—

Type of Car.	Gauge Width, cm.	Wheel Base, cm.	Mean Wheel Diameter, cm.
2-seated	120	160	110
4-seated	130	173	120
6-seated, small delivery van	140	187	150
Omnibus, heavy waggon	150	200	180

For dynamical reasons the front and back wheels should be of the same size. Unless a car can be built with wheels 250 cm. diameter, all hope must be abandoned of building electrical vehicles for cross-country purposes similar to benzine cars capable of 160 km. on one charge, at 32 km. per hour.

E. H. C.-H.

588. *Lombard-Gerin System of Electric Automobiles.* **J. G. W. Aldridge.** (Elect. Rev. 47. pp. 479–481; Discussion, pp. 481–482, Sept. 21, 1900. Paper read before the British Association.)—The author describes a system of electric motor cars now in operation near Paris, and intended to replace the ordinary form of overhead electric tramways. The car is in the form of an omnibus with solid rubber tyred wheels, weighs empty 3 tons and loaded 5 tons, and is propelled by a motor developing up to 15 b.h.p. geared to the rear road wheels. Current at 500 volts is supplied by means of a special form of trolley and connecting cable, the trolley being driven by an independent three-phase motor, gearing frictionally with two rollers running on the + and — overhead conductors respectively, these rollers being the collector for conveying current to the car motor. The trolley complete with its motor weighs 40 lbs. The cable leading to the car contains six conductors—two conveying direct current to the car motor, three conveying three-phase current back to the trolley motor, and one for actuating an electromagnetic brake on the trolley motor. A special feature is the neat and inconspicuous arrangement of the trolley wires, which are suspended from short arms on poles at the side of the road.

hen two cars going in opposite directions meet at a stopping-place the lley cables have to be exchanged ; this is a simple operation, but for town ffic it is preferable to have trolley wires at either side of the road, so that up and down traffics are quite independent. Several photographs of line and trolley are given [see also Abstract No. 1380 (1900)].

C. R. D'E.

589. *Calculations for Automobiles.* **W. Kummer.** (Elektrotechn. tschr. 21. pp. 346–347, May 3, 1900.)—By elementary methods the author duces relations between the constants of the "accumulator," of the whole omobile and of the track, whereby all questions as to construction and use automobiles can be theoretically answered. The calculations are applicable all kinds of automobiles other than those which take in energy from an ernal source while moving. By "accumulator" the author denotes the ly which contains the store of energy. Let P be the weight in kg. of complete automobile ; p, that of the accumulator, whose "output-efficient" in watts per kg. is K_L and whose "energy-coefficient" in watt-urs per kgm. is K_A ; v, the speed in km. per hour ; T, the time in hours of complete discharge of the accumulators ; N, the distance in km. covered in time T ; η, the ratio of the energy at the wheel rims to the energy at the minals, or valves, of the accumulator ; s, $= \tan \alpha$, α being the slope of the k whose traction-coefficient is f. If L is the number of watts given by accumulator at a given moment, then—

$$K_L = \frac{L}{p} \qquad (1)$$

if A is the total number of watt-hours obtained from one complete charge of the accumulator—

$$K_A = \frac{A}{p} \qquad (2)$$

—o—

$$T = \frac{A}{L} = \frac{K_A}{K_L} \qquad (3)$$

—

$$T = \frac{N}{v} \qquad (4)$$

any moment, we have—

$$L = P.v.\frac{f+s}{\eta}.\frac{9810}{3600} \qquad (5)$$

ence by substitution and transposing we get—

$$PN = p.K_A.\frac{\eta}{f+s}.0{\cdot}367 \qquad (I.)$$

ere $(f+s)$, v and L are assumed constant over the whole distance N. If p, K_A, η and $(f+s)$ are constant, equation I. determines the relation ween the variables P and N. Under these conditions the speed is found equating (3) and (4), whence—

$$v = N.\frac{K_L}{K_A} \qquad (II.)$$

ere—

$$K_L = f(K_A) \qquad (III.)$$

se equations, I., II., and III., enable us to solve two general propositions : What accumulator must be employed in order to move a given automobile

at a given speed over a given track with a given load? (ii) What automobile must be employed in order that a given accumulator may move it at a given speed over a given track?

In the second case of the electric automobile, we have—

$$K_A . (K_L)^n = c \qquad (III.a)$$

where n and c are constants, n lying between $\frac{1}{2}$ and $\frac{2}{3}$. As an example, an empirical curve connecting K_A and K_L is given for a modern French electric automobile, in which $p = 750$ kg., $P = 2{,}250$ kg., $\eta = 0{\cdot}70$, and $(f + s) = 0{\cdot}025$. When K_L is 2 and K_A is 16, N is 55 and v is 7, but when K_L is 10 and K_A is 10, N is only 38 though v is 35.

By considering a varying gradient as made up of sections over each of which $(f + s)$ is constant, the above formulæ can be applied to cases where $(f + s)$ is not constant by dividing the route into small sections over each of which it is constant. E. H. C.-H.

590. *Postel-Vinay Electric Waggon.* (Automotor Journal, 5. pp. 114–115, Dec., 1900.)—This vehicle is at work in Paris carrying loads up to 10 tons, and its total weight loaded is 22 tons. Its normal run is about 21 miles at 5 miles per hour. The batteries are of the "Phénix" type, weighing about $1\frac{3}{4}$ tons, or with the containing box in which they are placed under the centre of the frame, about $2\frac{1}{2}$ tons. Two motors of the four-pole type with slotted drum armature are used, each capable of generating 10 b.h.p. normally, or up to 30 b.h.p. for a few minutes. They each weigh about 1,000 lbs. and run at a normal speed of 800 r.p.m. The speed control is on the series-parallel system. The steering wheels are separately pivoted, and are steered by an auxiliary 3 h.p. electric motor. A magnetic brake is provided in addition to mechanical rim brakes. Very complete drawings are given showing the details of the under-carriage and running gear. E. J. W.

591. *Wade Electric Controller for Automobiles.* (Automotor Journal, 5. pp. 139–140, Dec., 1900.)—This article relates to a car built by the Electric Motive Power Company, but is almost entirely occupied with a description of the controlling system employed. The various speeds are obtained by coupling the cells in six, four, three, and two parallels, and the speciality consists in so arranging the controller connections that a passage from one speed to another can be effected without breaking the motor circuit, thus eliminating sparking at the contacts and jarring of the car. This is accomplished by introducing between the working combinations, intermediate "pass-over" combinations in which some portion of the battery is always in circuit. Diagrams are given showing the grouping for each combination and the connections to the controllor. E. J. W.

ELECTRIC LAMPS AND LIGHTING.

592. *Street Lighting at Grand Rapids, Michigan.* **G. A. Damon.** (Amer. Electn. 12. pp. 459–464, Oct., 1900.)—The plant cost $180,000; the 500 lamps used are direct-current enclosed arcs, taking 6·5 amperes at 70 volts. The population is about 100,000, and there are 283 miles of streets. Forty very high towers of open ironwork support four lamps each; forty of the lamps are suspended on ornamental poles of wood and iron, and the rest are hung from cross-suspensions. Fletcher automatic suspension pulleys are used. In

ge generating station there are six 150-light dynamos belted to three engines. he dynamos are of the Brush multi-circuit type, rated at 10,500 volts and 5 amperes when running at 500 r.p.m. Each machine has two separate rcuits, so that the line voltage may be kept down to half the maximum. he two circuits are controlled by one regulator at the dynamo. The range regulation is sufficient for 175 lamps. The engines are Russel horizontal ndem-compound, used with a Wainwright surface condenser. There are ir 150-h.p. Cahall horizontal water-tube boilers, with a Green economiser. he stack is of steel, lined with brick to the top. A test of the plant gave the llowing results :—

Efficiency (output on switchboard to i.h.p.)	.....	76 per cent.
Steam used by engine per kw. hour	.....	26·6 lbs.
Total steam per kw. hour, including condenser	.....	27·5 „
Coal per kw. hour (wet)	.....	4·53 „
Kilowatts per lamp	.....	0·43

he working expenses are $48·6 per lamp per annum. W. H. E.

593. *Street Lighting by Electric Lamps.* **F. H. Minshall.** (Elect. World d Engineer, 36. pp. 836–839, Dec. 1, 1900.)—The article deals mainly with he matter of alternate-current arc lighting for streets, and gives the results of he author's experience at Croydon. The following table gives approximately he energy required in a few types of alternate-current arc lamps in common se :—

No.	Type.	Current.	Volts.	App. watts.	Actual watts.	Power. factor.
1.	Rectified current, open arc ...	11·8	47	550	520	0·95
2.	Enclosed alternating.....	4·7	200	940	650	0·69
3.	Low wattage chokerless type	3·0	200	600	420	0·74
4.	Series alternating enclosed arc	10·0	70	700	530	0·76
5.	Enclosed alternating.....	6·7	115	770	510	0·66
6.	„ „	4·4	206	906	540	0·60
7.	Alternating, open arc series...	21·0	37	778	550	0·71

ghting is required for about 3,710 hours in the year, supposing the lamps run from dusk to daylight. On this basis the runing cost per year works t as follows, assuming the energy to be supplied at about 1½d. per unit :—

		£	s.	d.
For a 550-watt rectified current open arc	.....	22	10	0
For a 450-watt alternating current enclosed arc	.....	16	10	0
For a 650-watt „ „ „ „	.....	22	0	0

is includes the cost of carbons, and presumably the cost of trimming the mps ; but does not allow anything for the share of station plant used in nerating the necessary energy. Various systems of running alternate-rrent arcs in series or in parallel are generally dealt with. The article also ntains various calculations with a view to determining the most economical nditions of working, the most suitable size of cable for connecting lamps in ies, and other points in connection with the operation of lighting circuits.

W. H. S.

TELEGRAPHY AND TELEPHONY.

594. *Wireless Telegraphy.* **W. B. v. Czudnochowski.** (Phys. Zeitschr 2. pp. 105–107, Nov. 17, 1900.)—For a simple apparatus to demonstrate wireless telegraphy, the writer reverts to the Leyden jar arrangement used by O. Lodge in his original work on electrical resonance. Of various forms described, the best is said to be that in which two jars are used. The inner of the first is connected to a vertical exploring wire which ascends free into the air. The inner of the second is connected to earth. Both outer coatings are insulated from the earth. They are connected respectively one to each of the secondary terminals of an induction coil by equal wires carefully tuned. R. A.

595. *Cable Duplex with Intermediate Land-Line.* **A. Davidson.** (Electrician, 46. pp. 268–269, Dec. 14, 1900.)—A diagram is given showing the application of Harwood's duplex system to composite circuits composed of submarine cables and land-lines working with siphon-recorders. In the case considered, a cable AB is supposed to be connected through a land-line BC to a second cable CD, so that B and C are the terminal stations of the land-line. Signals from D, received at C in the usual way, are transmitted direct to A. Similarly, signals from A are transmitted by B to D. In order to record what is passing through, and to show the state of the balance, the land-line recorders at B and C are permanently in circuit. If the recorder at B is practically unaffected when B is sending to D, while signals from C to A are of legible size, the same state of things obtains at A, and duplex working is possible. The arrangement can be divided up for sectional working by introducing earths at B and C on the apex to apex lead. The principal source of disturbance is the variation of insulation of the land-line, but the recorders at A and D are so far away from one another, electrically, that the land-line balance must be out very considerably before the incoming signals are affected. The effect of the cable capacity can generally be sufficiently compensated, as regards the land-line balance, by tapping on a large capacity near the end of the land-line artificial lines. The lower the resistance of the land-line, the better the balance. Well insulated batteries at B and C are essential. On a duplex human relay system the arrangement amounts practically to the elimination of one station without introducing any extra contact or moving parts. The system has been worked successfully over a tropical land-line subject to heavy varying leakage. R. A.

REFERENCE.

596. *Telegraphs and Telephones at the Paris Exhibition.* **J. Gavey.** (Inst. Elect. Engin., Journ. 30. pp. 73–92; Discussion, pp. 93–103, Dec., 1900.)—Amongst others the systems of Rowland, Mercadier, Virag and Pollak, and Poulsen, are described, as also some accessories.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1901.

GENERAL PHYSICS.

597. *New Method for Vortex Rings.* **P. Czermak.** (Akad. Wiss. Wien, tz. Ber. 109. IIa. pp. 878–890, June and July, 1900.)—The method here escribed for producing vortex rings in the air consists in striking the elastic ack of a Tait's chamber by a bent lever, actuated by a weight falling through given height, which may be varied at will. In order to detect the rings ithout their being coloured by smoke, they were shot against a blackboard usted over with lycopodium. E. H. B.

598. *Specific Gravities of the Halogens and of Oxygen and Nitrogen at their oiling-points.* **J. Drugman** and **W. Ramsay.** (Chem. Soc., Journ. 77. and . pp. 1228–1233, Nov., 1900.)—To determine the specific gravities of liquid dine at its boiling-point the authors employ a small glass bulb with a pillary tube bent twice at right angles. After measuring the capacity of the lb, the latter is filled with the liquid, heated in a wide tube containing the oiling liquid until it assumes the temperature of the surrounding vapour and en allowed to cool, when the weight of the contained halogen is determined. the case of chlorine and oxygen a thermometer bulb was made use of, the em being bent as before, whilst with nitrogen the vapour-jacket was spensed with. It has been stated by Moissan and Dewar that, at —190°, nber agrees almost exactly in density with liquid fluorine. The specific avity of the latter is hence approximately measured by the authors by mparing the specific gravity of amber with that of liquid oxygen, the oiling-point of which is slightly higher than that of fluorine. The following ble gives the mean specific gravities of the various liquids at their boiling-ints under atmospheric pressure (760 mm.) :—

Iodine.....	3·706	Oxygen.....	1·1316
Chlorine.....	1·5071	Nitrogen	0·7914
Fluorine.....	1·108 (about)		

ne value for nitrogen is much lower than those given by Wroblewski (0·83 der 1 atmosphere) and by Olszewski (0·886 under 748 mm. and 0·859 under 0·9 mm. pressure).

The above results, together with others previously determined, lead to the following specific and molecular volumes :—

	Specific volume.	Molecular volume.
Nitrogen	1·390	39·04
Phosphorus	0·6734	41·82
Oxygen	0·8838	28·28
Sulphur	0·6757	43·20
Fluorine	0·9025	34·30
Chlorine	0·6635	47·04
Bromine	0·3392	54·26
Iodine	0·2698	68·46

T. H. P.

599. *Solar Radiation.* (Brit. Assoc. Report, 1900, pp. 36–45.)—This report of the British Association Committee describes the work of the year both in actual observations of solar radiation and in the improvements effected in the instruments used. It is found preferable to employ Callendar's automatic recording instrument for direct exposure to sunshine and to calibrate the receivers in absolute measure by other experiments. As much as 40 per cent. of the whole vertical component of radiation is sometimes found to come by reflection from the sky. E. H. B.

600. *Graphometer.* **V. Hensen.** (Zeitschr. Instrumentenk. 20. pp. 357–360, Dec., 1900.)—This is an instrument for graphical interpolation and curve measurements, a complement to Amsler's polar planimeter. Two advantages are claimed. Distances are marked by needle-pricks and measured on the needles; and two milled wheels are applied which always tend to keep parallel to one another. It is constructed by Zwickert, of Kiel. H. B.

601. *Rain Formation.* **H. Mache.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 793–798, June and July, 1900.)—In the neighbourhood of a drop of water of radius r, the vapour pressure p is increased, by surface tension, by $\Delta p = 2\omega a/(w-\omega)r$, where a is the capillary constant and w and ω are the specific volumes of the steam and the water. In air supersaturated with vapour, there will be a critical radius ρ for which the capillary and the saturation pressures will balance one another. Drops of larger radius will grow by condensation, and of smaller radius will evaporate, the latter the more rapidly per surface unit the smaller the radius. Hence only water-drops of a radius greater than ρ can serve for condensation nuclei in a supersaturated atmosphere. A rain-cloud may be likened to a layer of air, supersaturated with moisture by a fall in the temperature, containing condensation nuclei which will grow until they have passed by gravity out of that layer. On their further descent their radii will not change much. The author calculates that there should be far more large than small drops. C. T. R. Wilson has assigned to his nuclei a radius ρ of 10^{-7} cm. The author thinks that, for rain-formation, the ρ must be greater and lie between $1{\cdot}2 \cdot 10^{-4}$ and $2{\cdot}4 \cdot 10^{-5}$; for an extreme case of supersaturation, caused by a sudden temperature fall from 20 C. down to 0° C., the ρ would only be $8{\cdot}7 \cdot 10^{-6}$. It would therefore appear that the condensation nuclei must be dust particles, and not molecular aggregates of the highest orders. H. B.

602. *Fog Studies on Mount Tamalpais.* **A. G. McAdie.** (Monthly Weather Rev. 28. pp. 492–493, Nov., 1900.)—Further remarks on fogs near San Francisco and the remarkable topography of the district [see Abstract No. 2389 (1900)]. A kite meteorograph has frequently been attached to the top of a car of the train which descends the 8 miles from the observatory, at an elevation of 724 m., down to sea-level in 50 minutes, cutting through the fog. The afternoon fogs of the Bay seem to be due to mixtures of air masses (von Bezold) rather than to radiation and expansion, whilst the winter fogs of the Sacramento and San Joaquin valleys are apparently pure types of radiation fogs, the process of cloud-building going on from the cooled ground upward. One of the four photographic plates shows very well the air-waves (Helmholtz) of fog-clouds and their surgings and splashings. H. B.

603. *Sea-Waves of the Japanese Earthquake of June 15, 1896.* **C. Davison.** (Phil. Mag. 50. pp. 579–584, Dec., 1900.)—The epicentre was situated east of Kamaishi (which was destroyed by the sea-waves), at a depth of 4,000 fathoms near the foot of the western slope of the Tuscaroora Deep; the time was 10h. 31mins. a.m. G.M.T., and only two self-recording tide gauges mark the sea-waves, those at Honolulu and at Sausalito (entrance of San Francisco Bay); the latter was then the only automatic gauge in operation on the Pacific coast of the United States. The records are reproduced in this paper. There are no islands at all along the great circle, joining the epicentre to Sausalito; the mean ocean depth along that line is 17,000 feet, while the formula $\sqrt{gH} = V$ (in which H is the uniform ocean depth in which waves would travel with the same mean velocity V as that of the seismic sea-waves) yields 13,778 feet, *i.e.*, about $\frac{4}{5}$ of the measured value. The author had previously shown that the calculated values should be considerably less than the true mean depth. From the Honolulu records a mean depth of 14,492 would result. The epicentre line follows the long chain of islands of which the Hawaiian Islands form the eastern end. The mean depth on that great circle is 13,500 feet; if the earliest waves that reached Honolulu deviated a little from that line, however, they would pass through much deeper water. H. B.

604. *West Indian Hurricanes.* **E. B. Garriott.** (U.S. Weather Bureau, Bull. H. 232. pp. 3–69, 1900.)—The author reviews papers on this subject, beginning with W. C. Redfield (1821) and W. Reid, and dealing very fully with Benito Viñez, of Havana. The magnitude and force of a hurricane is, in the opinion of the latter, always proportional to the magnitude and perfection of the precursory cirri, and their divergence focus shows the bearing of the vortex. E. del Monte and Halkzenbrich, also of Havana, confirm these views. Lists of hurricanes are given, reproducing those of A. Poëy (enumerating 355 storms between 1493 and 1855) and of others, and descriptions of notable hurricanes, partly in monthly arrangement. Out of the 95 West Indian hurricanes traced during the last twenty-three years, 76 had a recurve to the northward; during the principal months, August to October inclusive, the hurricanes generally recurved east of the Gulf of Mexico, and their mean tracks shifted further west as the season advanced. Yet the charts show that hurricanes may spring up during these months in any part of the region between the 13th and 25th parallel, east of the 80° meridian. The theory is hardly touched upon. H. B.

605. *Daily Temperature Variations in Lake Wolfgang.* **F. M. Exner.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 905–922, June and July, 1900.)—A

preliminary account is given of observations made during the summer and autumn of 1899 in Lake Wolfgang, Salzburg, at a spot 15 m. from the bank, in water having a depth of 9 m. Bolometers were used with thin platinum wires connected by constantan wires with a Wheatstone bridge; the wires were well covered with rubber bands and tubing; temperatures could be determined within 0·03° C. Five bolometers were arranged in a vertical line at depths of 24, 87, 149, 274, and 524 cm. It was ascertained that the direct sun rays did not raise the bolometers to a higher temperature than the surrounding water; the wire connections in the air did not cause any trouble. It further resulted that it did not matter whether psychrometer tests were conducted on the lake or on the land. The paper tabulates the uninterrupted observations from August 29th to October 3rd. The water temperature curves are, of course, much smoother than the air temperature curves, but they show the chief variations. The afternoon maximum of the water coincides with the air maximum. Conduction, therefore, plays no part —convection could be evident in the case of cooling only—and hence the lower water strata appear to be essentially heated by radiation. The temperature variations decrease very rapidly with increasing depths, but the radiation was still noticeable at a depth of 5·2 m. H. B.

606. *Barometric Variation with Synodic Revolution.* **A. Poincaré.** (Comptes Rendus, 131. pp. 1262–1264, Dec. 24, 1900.)—This paper gives the results of a further investigation than that mentioned in Abstract No. 617 (1900). Tables are given showing the differences from the mean variation in two regions, one in the temperate zone about 40° lat., the other polar. The effects in the polar region are the reverse of those produced in the temperate locality. Generally in the temperate region the difference between the extreme values attains a *minimum before* the *first quarter* and *after the second*, &c. C. P. B.

607. *Variation of Latitude.* **J. K. Rees.** (Amer. Phys. Soc., Bull. 1. pp. 34–36, 1900.)—This paper gives the results obtained at the Columbia University from May 1, 1893, to July 1, 1894. The observations are divided into four series, and the variations found are given in tabular form. The value of the "*constant of aberration*" determined was 20·464″ ± 0 006.″ C. P. B.

REFERENCES.

608. *Apparatus for Impact Tests of Materials in Tension.* **W. K. Hatt** and **W. P. Turner.** (Railroad Gazette, 32. pp. 766–767, Nov. 23, 1900. Extracts from a paper read before the Paris International Congress for the Unification of Tests of Materials.)—This describes a permanent apparatus constructed in place of a temporary apparatus built of wood [see Abstract No. 1236 (1900)] for testing the behaviour of iron and steel under impact in tension. The permanent apparatus is similar to the temporary one in principle but is constructed of iron, and arranged so as to make the testing of samples able to be done more quickly than with the original form. E. C. R.

609. *Stationary Radiants of Shooting Stars.* **T. Brédikhine.** (Acad. Sci. St. Pétersbourg, Bull. 12. pp. 95–120, 1900.)—This paper, being an analytical one, is unsuitable for condensation; it gives a full discussion of the various examples cited for explaining the phenomenon, and a most useful series of references to existing literature on the question. C. P. B.

LIGHT.

610. *Application of Fourier's Double Integrals to Optical Problems.* **C. Godfrey.** (Roy. Soc., Phil. Trans. 195. pp. 329–362, Dec. 24, 1900.)—Gouy has pointed out in a passage quoted by the author that ordinary light does not consist of an infinite series of regular undulations, such as originally treated of in the undulatory theory, and Gouy suggests the analysis of disturbances by Fourier's theorem as a means of adapting the theory to the explanation of actual phenomena. This is the method followed in the present treatise. The writer deals in this place solely with plane and plane-polarised light.

The fundamental theorem is one due to Rayleigh and Schuster, namely, that if—

$$f(t)=\int_0^\infty R_1 \cos(ut+\psi_1)du$$

$$\phi(t)=\int_0^\infty R_2 \cos(ut+\psi_2)du$$

where R_1, R_2, ψ_1, ψ_2 are functions of u, then—

$$\int_{-\infty}^{\infty} f(t)\phi(t)dt=\pi\int_0^\infty R_1R_2\cos(\psi_1-\psi_2)du,$$

and therefore if $f(t)$ and $\phi(t)$ denote the same function—

$$\int_{-\infty}^{\infty}\{f(t)\}^2dt=\pi\int_0^\infty R^2du,$$

It follows that in integrating the energy of a system of waves over any time (and such integrated energy is what we directly observe) differences of phase disappear, and the result depends only on the distribution of energy among the different elements of the Fourier integral. This result is applied to (1) Interference; (2) The influence of light on a vibrator.

The author next considers radiation composed of a random aggregate of pulses with reference to the papers of Lommel (Wied. Ann. 3. 251, 1878) and Rayleigh (Phil. Mag. 27, 1889), and to J. J. Thomson's explanation of the phenomena of the Röntgen rays as arising from a series of electric pulses.

Thomson's theory on this subject is separately discussed in sections 31, 36, and compared with Stokes's explanation of the same phenomena.

The author then proceeds to the radiation of an incandescent gas. The molecules are supposed, according to the usual theory, to spend their time between relatively long "free paths," and relatively—in this treatise infinitesimally—short periods of time during which they are in encounter with other molecules. By such an encounter this molecule is set vibrating and continues during its free path to send out trains of waves which represent the effect on ether of such vibration. Such a train of waves has therefore a definite beginning and a definite end, and may be represented by the appropriate Fourier series. The radiation observed will thus consist of a

great number of finite trains superposed. But as the velocities of the molecules are comparable with that of radiation, the apparent frequency will depend in some degree on the velocity of the molecule and the angle which its direction makes with the line of sight. These trains are analysed by Fourier's theorem. The effects are summed up for all molecules having definite velocities, both athwart and in the line of sight, Tait's results obtained for elastic spheres being employed for this purpose.

The writer then considers the Visibility Curve, discussing Michelson's papers (Phil. Mag. 31 and 34). The case of zero pressure is considered by the help of Tait's tables (Edinbro Phil. Trans., vol. 33).

The writer treats of the effect of Damping on the width of spectrum lines, obtaining the result, which Lommel had given after a less complete analysis, that the spectrum lines are widened through damping.

Next is discussed the character of the ether motions in nearly homogeneous light. The view that the possibility of producing a large number of interference fringes from white light indicated a certain regularity in the ether motions has been, the writer says, refuted by Gouy, Rayleigh, and Schuster. This question is discussed by means of Fourier's integrals.

The paper ends with a discussion on the effect of natural light on a vibrator. The equation of motion of the vibrator is taken to be—

$$\ddot{x} + 2\kappa\dot{x} + p^2x = f(t) = \int_0^\infty \mathrm{R}\cos(ut + \psi)du.$$

But this is given as a hypothesis only, assuming that a molecule can be regarded as a simple vibrator. The writer considers in this relation Sellmeier's treatment of the subject of dispersion, pointing out an error into which Sellmeier has fallen that the natural vibration of a molecule under the influence of constant light will be insignificant compared with the forced vibration. The result here obtained is that, so far as the theory of the vibration carries us, the natural vibration may be as prominent as the forced vibration. [See also Abstract No. 820 (1900).] S. H. B.

611. *Reflection of Light in the Neighbourhood of the Critical Angle.* **J. G. Coffin.** (Technology Quarterly, 13. pp. 139–144, 1900.)—This paper gives the results of a calculation of the percentage of light reflected on passing from a dense to a rare medium at various angles of incidence from 0° up to the critical angle. It is noteworthy that the proportion of reflected light increases but very slowly as the angle of incidence increases until within about 10° of the critical value, when there is a sudden and marked increase. The results are shown on a curve in which the ordinates represent the percentage of reflected light and the abscissæ the angles of incidence. The index of refraction is taken as 1·5. The tangent to the curve near the critical angle is nearly perpendicular to the axis of abscissæ. A change of less than 1° in the angle of incidence near this point increases by 50 per cent. the amount of reflected light. J. J. S.

612. *Refraction of Hydrocarbons with Condensed Benzene Nuclei.* **A. Chilesotti.** (N. Cimento, 12. pp. 290–293, Nov.–Dec., 1900. From the Gazz. Chim. Ital. t. 30. I, 1900.)—Results are given of the measurements of the refractions of dibenzyl, stilbene, tolane, phenanthrene, retene, and fluorene in benzene solution, and of anthracene in naphthalene solution, the influence of the solvent on the refraction being allowed for by means

of Landolt's formula for mixtures. In the following table the mean experimental numbers are given for the line H_α according to both the Gladstone and the Lorenz and Lorentz formulæ, and for the specific dispersion (H_A) according to the Gladstone expression; the values calculated from the structural formulæ are also given, the atomic refractions used being as follows: For the Gladstone formula—carbon 5, hydrogen 1·30 and a double linking 2·40; for the Lorenz and Lorentz formula—carbon 2·48, hydrogen 1·04 and a double bond 1·78.

	$M(\mu_{H_\alpha}-1)/d$.			$M(\mu_{H_A}-1)/d$,			$M(\mu^2_{H_\alpha}-1)/(\mu^2_{H_\alpha}+2)d$.		
	Found.	Calc.	Diff.	Found.	Calc.	Diff.	Found.	Calc.	Diff.
Dibenzyl	103·83	102·60	1·23	101·55	101·50	0·05	59·59	59·96	0·37
Stilbene	115·43	102·40	13·03	113·39	101·00	12·39	65·44	59·66	5·78
Tolane	111·70	99·64	12·06	—	—	—	62·07	58·02	4·05
Anthracene ...	109·34	97·40	11·94	100·3	—	—	61·15	55·80	5·35
Phenanthrene..	110·70	99·80	10·9	108·31	98·4	9·91	61·59	57·58	4·01
Retene	145·12	130·2	14·92	—	—	—	80·64	75·82	4·82
Fluorene	98·30	92·40	5·90	97·49	91·20	6·29	55·28	53·32	1·96

From these numbers it is seen that of the compounds given, dibenzyl is the only one which obeys the laws of Landolt and Brühl. The values in the above table differ somewhat from those obtained by Gladstone in 1870, the greatest deviation being in the case of anthracene, for which Gladstone found the molecular refraction 100·3.

Taking the centric formula for the benzene nucleus, the refractive value of each centric linking is for naphthalene, anthracene, phenanthrene, and pyrene, 1·39, 1·46, 1·54, and 1·48 respectively, the Gladstone molecular refraction formula being used; with the Lorenz and Lorentz formula the value is even more constant, the numbers for each centric linking being for benzene 0·89, naphthalene 0·90, anthracene 0·89, and phenanthrene 0·90. Hence centric structural formulæ for aromatic hydrocarbons accord best with their optical properties. T. H. P.

613. *Refraction by Ethyl-Ether near its Critical Point.* **B. Galitzine** and **J. Wilip.** (Acad. Sci. St. Pétersbourg, Bull. 11. pp. 117–196, Oct., 1899.)—An account is given of experiments conducted with the object of measuring directly the indices of refraction of ethyl-ether and its saturated vapour for temperatures in the neighbourhood of the critical temperature. Two methods were employed. In one (see Acad. Sci. St. Pétersbourg, Bull. 3. p. 131, 1895) the tube containing the substance under investigation was employed as a cylindrical lens; silver was deposited on the back of the tube and two parallel lines drawn on the silver; from the observed distance between the images of these lines at any part of the tube the index of refraction of the corresponding layer of the substance in the tube was calculated. A special thermostat was employed, consisting of two semicircular vessels containing glycerine and surrounded by two similar ones in communication with a vessel containing naphthaline boiling under pressure; these vessels were fastened together, but separated by parallel plane glass panes, the tube under investigation being placed in the centre of the circular vessel so formed, and air being excluded above and below by packing with cotton-wool; any temperature between 180° and 200° C. could thus be maintained with variations hardly exceeding 0·05° C. Stirrers were placed both in the

thermostat and in the tube. Monochromatic light corresponding to the red lithium line was used. The constants of the instrument were determined by observations on substances of known refractive index. Series of experiments were conducted with ordinary and specially prepared glass tubes and with and without the stirrer in the tube being used. Errors in the calculated refractive index were estimated to be of the order 0·005 owing to the uncertainties in the constants of the apparatus, and of the order 0·001 owing to errors of observation. The observations show that with a good thermostat and thorough mixing of the different layers in the tube the critical temperature may be determined by this method, with a possible error between 0·1° and 0·2° C. It is also found that in an interval of temperature from a little below the critical point (the fluid being compressed) to about 4° C. above the critical temperature the index of refraction is completely independent of the temperature and a function of the total volume only. Lorentz's formula, $\frac{x^2-1}{x^2+2}v = C$, connecting the index of refraction x, and the density of the substance $\left(\delta = \frac{1}{v}\right)$ is verified for a wide range of temperature, and the value $C = 0{\cdot}3025$ determined from a large number of observations. When the stirrer in the tube is not used, the index of refraction is found greater in the lower layers both for the liquid and vapour and for temperatures below and above the critical temperature. The differences are large and beyond the limits of error, and therefore the ordinary methods for the determination of the critical constants of substances depending on the vanishing of the meniscus between the liquid and its vapour are only accurate when thorough mixing of the different layers is ensured. Also observations of a sudden great change of refractive index at places where the meniscus has vanished on passage through the critical point seem to show that the fluid phase persists above the critical temperature, and that a delay in evaporisation occurs. Three hypotheses as to the cause of the observed differences of density are discussed and found to be unsatisfactory, viz., that they are due (1) to inequality of temperature; (2) to gravity; and (3) that the differences in the values of the refractive index arise from traces of air being present.

In the second method a thin prism was placed in the tube containing the ether with its edge parallel to the wall of the tube, and the deviation occurring in a horizontal beam of light, after passing through any layer of the substance in the tube, was measured, and the corresponding refractive index was thence calculated. The method was found not to afford the same degree of accuracy as the first method, but the conclusions drawn from the previous observations were confirmed. W. E. T.

614. *Goniometer.* **J. Domke.** (Zeitschr. Instrumentenk. 20. pp. 360–362, Dec., 1900.)—This is a simple mirror instrument, known as pantogon and constructed by G. Meissner, of Berlin, for measuring angles up to 300° within one minute of arc without the use of a telescope. Both metallic mirrors are perpendicular; the movable one has a line at the level of the upper ridge of the fixed mirror. The instrument can also be applied for the survey of coasts and for determining on board ship the height of a promontory. H. B.

615. *Stereoscopic Röntgen Ray Apparatus.* **H. Boas.** (Deutsch. Phys. Gesell., Verh. 2. 4. pp. 45–52, 1900.)—The author describes apparatus for casting images upon a screen from two points of view alternately, and glimpsing at them with the two eyes alternately through a binocular strobo-

scopic apparatus containing a revolving arrangement acting in synchronism with the alternations on the screen. Two distinct spark-inductors are used and alternately actuated by a turbine interrupter. A. D.

616. *Phosphorescence.* **G. le Bon.** (Revue Scientif. 14. pp. 289–305, Sept. 8; 327–341, Sept. 15, 1900.)—Phosphorescence due to the impact of ordinary light is familiar: that due to the action of infra-red rays or of heat may be readily studied by means of a lantern projection lamp darkened completely, with a biscuit-tin lid at the top; this lid is placed at about 65° when one wick is lit, 130° when two, and 225° when three are lit. If a slip of ebonite 0·5 mm. thick be slipped into the grooves, and held in place by two slips of glass, much infra-red radiation passes through, of wave-length 0·8 to 2μ, this being the infra-red radiation which can set up phosphorescence. The metal chimney sends out waves of from 5 to 6μ; but these do not produce phosphorescence. The observer must have been at least fifteen minutes in complete darkness, and must not himself see any light used to excite phosphorescence. Most bodies, under the action of light and some other causes, emit effluvia capable of rendering air conductive and of traversing material obstacles such as a sheet of metal, and of the same nature as those emitted by radio-active bodies. Phosphorescent bodies in nature—diamond (usually), apatite, fluorspar, leucophane, &c.—phosphoresce feebly; artificial ones—sulphides of alkaline earths, &c.—much more strongly. Evanescently phosphorescent bodies include fluorescent bodies; there is no real distinction; the rays which produce the effect extend from the blue to far into the ultra-violet. Sulphide of calcium begins to phosphoresce distinctly but faintly after $\frac{1}{30}$ second exposure to the sun; barium sulphide after a longer time; strontium sulphide after several seconds. Sulphide of zinc with *green* fluorescence—the stock of which has been used up and which the chemical works have not been able to reproduce, but of which Le Bon has some screens which he offers to physicists—has peculiar properties; when it is made to phosphoresce by sunlight the phosphorescence is extinguished by yellow, green, red, and particularly by infra-red, in which the extinction is perceptible in $\frac{1}{10}$ second. Rays from a petroleum lamp put out its phosphorescence: whereas the sulphides of Ca, Ba, and Sr are excited to phosphorescence by these rays. This sulphide of zinc is a detector of infra-red rays as that of calcium is of blue and ultra-violet rays. The spectrum from blue to ultra-violet excites phosphorescence; from green down to infra-red it tends to extinguish it: in an intervening portion, about line F, it excites phosphorescence up to a certain feeble intensity, but reduces to the same intensity any existing phosphorescence. Blue and violet (G to H) are much more active than ultra-violet in producing phosphorescence. A screen of the ZnS referred to does not phosphoresce in light passed through quinine sulphate solution; if phosphorescing, it is extinguished; the other sulphides react similarly, but a feeble phosphorescence is excited or remains as the case may be, and in the latter case the extinction is not only partial but slow. But if a tank containing a saturated ammoniacal solution of sulphate of copper (2 cm. thick) be interposed between the quinine solution and the zinc sulphide screen, sunlight will make the screen phosphoresce very brightly; the extinctive part of the spectrum has been cut off and the blue rays have acted in the absence of the ultra-violet, which has been cut off by the quinine solution. A piece of blue glass is not as good an absorbent of the extinctive rays, and the corresponding phosphorescence is less bright. With a screen of green-phosphorescent ZnS, directly exposed to the sun, the phosphorescence corresponds in brightness to 0·002 that of a

candle-flame : exposed to diffused light (which is bluer than direct sunlight) the brightness is 0·004 candle-flame ; to sunlight under cobalt blue glass, 0·014 ; to diffused light under cobalt blue glass, 0·018 ; to sunlight through a 2 cm. thickness of ammoniacal solution of $CuSO_4$, 0·028, fourteen times as great as in the first case. The other sulphides, being less affected by the extinctive rays, show no such marked differences. Sulphide of strontium and this particular sulphide of zinc give the same green tint ; but the former is easily excited by a candle, the latter is extinguished by it.

Exposure to the sun at different temperatures.—The phosphorescence increases from 0° to 100° ; beyond this it falls off and is zero at about 500°. The phosphorescence-light is then thrown off as fast as it is excited. At say —190° (liquid air) magnesium ribbon produces no phosphorescence ; but on allowing the screen to assume the surrounding temperature (which is equivalent to heating it through, say 200°) phosphorescence appears. Time has much less influence than temperature in causing loss of phosphorescence : at a very low temperature the loss is exceedingly slow ; at a very high temperature it is very rapid ; at intermediate temperatures it is first rapid and then asymptotic, leaving a certain residual phosphorescence the amount of which depends upon the temperature that is maintained. Sulphide of calcium at ordinary temperatures is considerably above the temperature at which it begins to phosphoresce, and therefore loses brightness steadily ; fluorspar and apatite do not phosphoresce below 50°, and time does not affect their phosphorescence. The temperature at which phosphorescence begins is in every case far below the temperature of incandescence, and phosphorescence is a "cold" light ; but it is too weak for practical use. This weakness is not, however, the cause of the temperature being apparently low ; but we do not know anything about the infra-red region of the phosphorescence spectrum ; the bolometer only shows us that the maximum energy of the light (from phosphorescent animals, Langley) is in the yellow, and in any case any small rise of temperature detected may be due to a concomitant phenomenon.

Invisible phosphorescence (light too faint to be seen) may continue for (eighteen or more) months, without any heating ; and the invisible rays may be refracted or polarised, and affect photographic plates. Further, the effect of exposure to light does not die out with the disappearance of invisible phosphorescence, for when even this has died out, certain dark radiations (wavelengths up to 2μ) may re-excite phosphorescence, up to the point of visibility. There is, therefore, some "residue" permanently left in the body, as the result of the momentary exposure to light ; but this can be dissipated by heat, or by repeating the above experiment, say fifty times, or by protracted exposure to the dark rays. Sulphide of zinc is not sensitive to infra-red radiations in this way : its residue can only be discharged by heating to 100°. Some striking experiments may be made, setting up phosphorescence in a dark room by means of rays from a darkened lamp passed through ebonite or a thick layer of Japan varnish : sulphide of calcium works best : and the phosphorescence set up is bright enough to enable a photograph of the phosphorescent screen or statuette to be taken in forty minutes. It is the impact of the particular dark waves that produces the temporarily revivifying effect and the partial or complete exhaustion of the residue, not the heat produced on the impact of these waves. Incidentally, the "heat-waves" are not necessarily the infra-red : they may be so when the source is at a low temperature ; but when the compression of the whole infra-red into a small space in the ordinary spectrum is taken into account, the maximum heating power in sunlight is found to be near line D. Most bodies are transparent to infra-red

rays as detected by this test, which is more delicate than the bolometer. The infra-red rays also destroy chlorophyll, prevent the formation of sugar in plants, and have a reversing action in photography. In wearing out the phosphorescence of a sunned screen, infra-red rays act more promptly than heat: they act through glass where ordinary heat rays (5 to 6 mm.) will not, at any rate until the glass is warmed so as to allow the screen itself also to become warm: they act upon sulphide spread upon glass (instead of card) where heat rays will not until the glass is itself warmed: with a sunned screen of the green-fluorescent ZnS the infra-red puts out the phosphorescence while heat increases it: and if the screen be maintained at 0° the infra-red waves still produce their effect. After exhaustive exposure to infra-red waves the CaS screen cannot be re-excited to phosphorescence unless its temperature is raised above 100°: and the infra-red waves have dissipated the residue to the same extent as heating to 100° would have done.

Sulphide of strontium heated so as to deprive it of all residue, and exposed to light for too short a time to enable visible phosphorescence to be set up, will phosphoresce if heated to 225°. It is in the condition of invisible phosphorescence. Natural minerals which become phosphorescent on heating lose this property if the heating be kept up, and only feebly regain it on being sunned: their "residue" is exhausted. It is very improbable that this residue was stored-up luminous energy: it might be a quantity of products of decomposition, capable of reunion, with evolution of light, when the temperature became high enough. The minerals examined (including fluorspar) all shine on heating; and after exhausting their "residues" by heating, they shine feebly on sunning. Chlorophane does not shine indefinitely in the dark at 30° as it is said to do: this part of its power of phosphorescing has long ago been exhausted; what the heat of the hand brings out is the effect of some previous exposure to light, and forty-eight hours in darkness is enough to wear this away. Minerals cut in the dark from the interior of very large lumps, and which have therefore not seen the light for ages, shine upon being heated as well as if they had recently been exposed to light. They appear to contain the products of decomposition referred to. These tend to recombine and to be re-formed under the action of light; promptly and completely, in those minerals which phosphoresce after exposure to light at ordinary temperatures; incompletely under light in those which require higher temperatures. The diamond presents a difficulty if it be considered as pure carbon, for its behaviour is like that of alkaline earth sulphides; its phosphorescence can be wholly regenerated by light. Cape diamonds are hardly perceptibly phosphorescent: Brazil diamonds are brightly so (except black diamonds) for half an hour, and thereafter the phosphorescence can be restored by heating to 200° at any time. When the phosphorescence thus restored is exhausted (one hour at 200°) it can be completely restored by sunning; and the same even after many hours' heating at 600°. If the phosphorescence be due to foreign matters, which give the diamond its tint, these must be refractory at the temperatures employed. Polished diamonds are not more phosphorescent than rough. On calcination, say for fifteen hours, minerals mostly lose all power of having their phosphorescence regenerated by light; the violet amethyst becomes as clear as glass, and appears to lose something essential: other substances can after this treatment have the power restored by passing electric sparks through them for some time; the longer the spark (up to 15 cm.) and the longer the time (say five minutes) the brighter the restored phosphorescence. It appears, however, that there must have been some trace of this power left in the body so treated perfectly pure sulphides of Ca, Ba, Sr,

and Zn, which are not phosphorescent, are not made phosphorescent by this treatment. In most cases calcination does not drive out the foreign components, but alters the chemical relations, which are restored by the electric sparks.

The "residue" of phosphorescent power stimulated into activity, say by a temperature of 100°, becomes exhausted if this temperature is kept up: when it is exhausted, a temperature of 200° will bring a fresh portion of the residue into play: and so on up to say 500° or 600°; but heating to 100° for months will not encroach upon that portion of the residue which comes into activity only at temperatures above 100°; and so forth. A body incompletely exhausted at 500° and then cooled down and reheated to 200° will not shine, for all that portion of the residue is exhausted. There is no real distinction between bodies phosphorescent under heat and those phosphorescent under light. A body cannot become luminous by phosphorescence unless it is warm enough.

Phosphorescence produced by shocks or blows appears not to be due to any localised high temperature, but apparently to a conversion of energy propagated after the fashion of an explosion. The oxygen of the air plays no part. The phosphorescence is brighter in a vacuum (mercury vacuum type). Uranium is phosphorescent by friction only: most substances in this class are phosphorescent under heat or light. Calcination does not interfere with the phosphorescent power under the head. Cape diamonds are very phosphorescent under friction.

Phosphorescence under Röntgen rays is very feeble, while fluorescence is bright. Kathode rays and high-frequency emanations also are noted.

Phosphorescence accompanying chemical reactions.—Oxidation (? hydration and dehydration, with production of PH_3) of phosphorus. Sulphate of quinine, heated 150° to 200° C., dehydration; again on hydratation by absorption of moisture on cooling and contact with damp air: and the heat as a dehydrator may be replaced by a little anhydrous phosphoric acid, with similar results. Sulphate of cinchonine the same. Ordinary magnesia, commercial sulphate of lime and hydrate of alumina phosphoresce on dehydration only, and this requires temperatures of about 500°. In living beings we probably have hydration and dehydration. In radio-active bodies we have a phosphorescence readily lost by hydration and by heat; which points to chemical reactions rather than to atomic properties as the cause: the energy being supplied by infra-red radiations from surrounding walls, these calling forth the reactions which result in phosphorescence.

Perfectly pure substances are not phosphorescent. Traces of other substances are necessary: sulphide of strontium, for example, needs one part per 10,000 of a salt of manganese or bismuth (Mourelo). Sulphide of calcium has different phosphorescences according to the source of the lime.

Phosphorescence of living beings is now known to be practically universal in deep-sea life (Monaco expedition collections). Luminiferous bacteria on stale fish: cultivated in flasks (Paris Exhibition "Lumière vivante"). The phenomenon survives the life of the animal, but deprivation of air and moisture stops it. The spectrum varies according to the animal. The light can be reflected and polarised. Stale fish can be photographed with two minutes' exposure. Phosphorescence is apparently due to chemical reactions (hydration and dehydration, possibly).

Fluorescence is explicable on principles of resonance: but protracted phosphorescence, visible and invisible, seems hardly so. It seems to be due to chemical reactions going on even within the solid, and yet extremely

mobile, so that they can be set up or arrested in fractions of a second, and reversible, but also dependent upon the temperature, so that the combination is promptly broken up by a very high temperature, slowly by a lower, and not at all at a sufficiently low temperature. This points towards some new field in chemistry, a region of unstable compounds where the singular action of mere traces comes into play. The author has already obtained some singular results in the chemistry of mere traces and their effect upon the elements with which they are combined. A. D.

617. *Fluorescence and Chemical Composition.* **J. T. Hewitt** and **B. W. Perkins.** (Chem. Soc., Journ. 77. and 78. pp. 1324–1334, Dec., 1900.)—It is well known that whereas the tetrabromo- and tetraiodo-derivatives of fluorescein show marked fluorescence in alkaline solutions, the corresponding nitro-compound exhibits no trace of this property. From experiments on di- and tetra-nitro-fluorescein, the authors conclude that the introduction of nitro-groups into the fluorescein molecule in the ortho-position relatively to the hydroxyl groups prevents fluorescence in alkaline solutions, owing to the usual phenol-lactone and quinonoid-carboxylic acid tautomerism of fluorescein being inhibited by a secondary tautomerism between the nitro- and phenolic hydroxyl groups. At the same time the pyrone ring is so much weakened that water is readily added on with production of a true phthalein. T. H. P.

REFERENCES.

618. *Apparatus for Comparison Spectra.* **W. H. Wright.** (Astrophys. Journ. 12. pp. 274–278, Nov., 1900.)—The new accessory apparatus, consisting of adjustable prisms and electrodes, made for the Mills spectrocope of the Lick Observatory, is described in detail with figures of the parts in position. C. P. B.

619. *Periodic Vibrations of a Line Spectrum.* **E. Riecke.** (Phys. Zeitschr. 2. pp. 107–108, Nov. 17, 1900.)—Modification of the differential equations by introduction of terms for acceleration. Full paper to appear in Annalen d. Physik [*cf.* Abstract No. 825 (1900)]. A. D.

620. *Incandescent Gas Mantles and Burners.* **V. B. Lewes.** (Soc. Arts, Journ. 48. pp. 841–847, Oct. 19; 853–859, Oct. 26; and 865–873, Nov. 2, 1900.)—This paper is a reprint of a series of three Cantor Lectures on the above subject. In the first Lecture the author traces the origin and development of the production of light by the heating of refractory bodies to incandescence and treats of the preparation and use of the "mantle," the employment of thoria as the basis of the mantle and the effects of traces of other oxides on the light emissivity of thoria. Descriptions of the various thoria-ceria mantles, such as the "Welsbach," the "Voelker," the "Daylight," and the "Crown" mantles are given. Lecture II. deals, firstly, with the several theories which have been advanced to explain the enormous increase of luminosity produced by the addition of one part of ceria to 99 of thoria in preparing the mantles. The view generally accepted at the present time is that of O. Bunte, who considers that the small quantity of ceria present causes a catalytic action of the same kind as the heating of clean platinum-foil by a stream of mixed coal-gas and air, the ceria being by this means heated to a higher temperature than that of the flame. Next the sources of the rare earths are treated of and the attempts made to improve, or alter the composition of, the ceria-thoria mixture; the use of collodion for the purpose of obtaining a coherent mantle is also dealt with. In Lecture III. are described the various forms of burner employed for heating the mantles and their modes of action. T. H. P.

HEAT.

621. *A New Recording Air Pyrometer.* **W. H. Bristol.** (Mech. Eng. 6. pp. 916–917, Dec. 29, 1900. Paper read before the American Society of Mechanical Engineers, N.Y., Dec., 1900.)—This instrument consists of a porcelain bulb connected by a capillary tube made of seamless copper to a recording pressure gauge. The recording gauge is constructed with two tube springs formed on the Bourdon principle. Each spring consists of a tube of closely flattened cross section made into a helix of two complete turns. One of these springs is attached to the capillary tube and porcelain bulb, and the air is almost exhausted from the system. Although this subjects the bulb when cold to almost the full atmospheric pressure, yet when it is heated and the remaining air contained in it expands, the effect is to expose the bulb when in a weakened condition to only a very small strain. The air is also partially exhausted from the other tube spring, which is mechanically attached to the free end of the indicating tube spring. The object of this is to fit it to act as a compensating spring for barometric and thermometric changes. It is fixed so as to turn in the opposite direction to the other spring when both are under the influences of these changes. Barometric and thermometric corrections being thus eliminated, it is only necessary to calibrate the instrument according to the theory of the air thermometer.

F. J. R.

622. *Compressibility of Fluids.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 837–848, June and July, 1900.)—From the equation of van der Waals, applied to rarefied gases, the author deduces the relations—

$$-\frac{1}{v}\left(\frac{\partial v}{\partial p}\right)_{T} = 12{\cdot}225m\frac{(v-a)^2}{Tv}$$

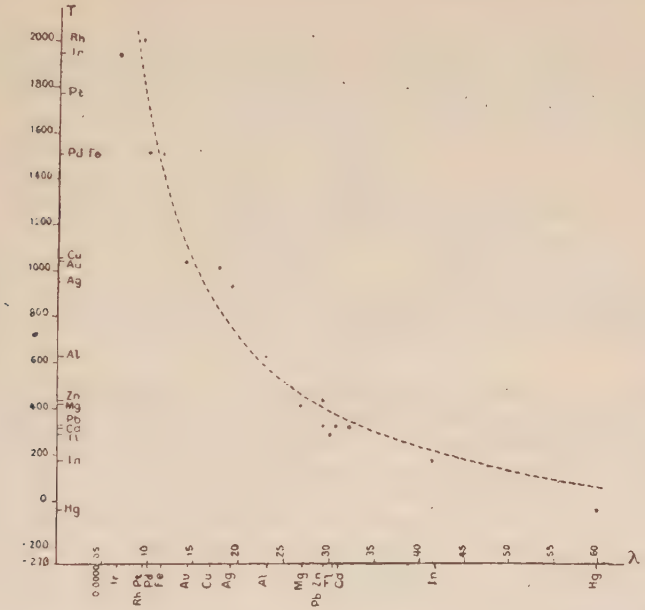
$$v_1 - v_n = 12{\cdot}225\ m\frac{(p_n - p_1)(v_1 - a)}{T}\ (v_n - a),$$

v being the volume in cubic metres of 1 kilogram of the gas, m its molecular weight, p being measured in atmospheres, and v_1, v_n being the specific volumes corresponding to pressures p_1, p_n. On comparison with the experimental results of previous investigators in reference to water, carbon bisulphide, mercury, the ethyl, methyl, amyl, and propyl alcohols, ethyl ether and benzene, it is found that the above formulæ may be made to represent the behaviour of the fluids by a suitable choice of the constant a.

Tables are given which show the close agreement at ordinary temperatures between the observed values of the coefficients of compression and those calculated from the formulæ. From the consideration of two vapours, at the same temperature, below their critical temperature, occupying equal volumes and under equal pressures, isothermally submitted to continually increasing pressure, it appears that the ratio of their ultimate volumes will be equal to the ratio of m_1a_1 to m_2a_2, where a_1 and a_2 are the values of the constant a for the fluids under consideration; therefore, the molecular volumes are in the same ratio and the diameters of the molecules as the cube root of this ratio. Thus the values of the constant a afford a means of comparing the size of the molecules of different liquids.

W. E. T.

623. *Relation between Coefficients of Expansion and Melting-points of Metals.* — **Lémeray.** (Comptes Rendus, 131. pp. 1291–1293, Dec. 31, 1900.)—From experimental data the author concludes that if pieces of different metals have equal volumes at absolute zero, their volumes will again be equal to one another



at their respective melting-points. Thus, if λ be the coefficient of linear expansion and T the absolute temperature, then $T\lambda$ = constant. The annexed diagram, in which the dotted line represents $T\lambda = 0{\cdot}02$, shows that in the case of the sixteen metals considered the conclusion is verified as accurately as could be expected. J. E. M.

624. *Critical Temperatures of some Sulphuretted Compounds.* **L. Ferretto.** (N. Cimento, 12. pp. 288–290, Nov.–Dec., 1900. From the Gazz. Chim. Ital. t. 30. I., 1900.)—The following results were obtained :—C_2H_5HS, 228° ; $(CH_3)_2S$, 231·2° ; $(C_2H_5)_2S$, 284·67° ; $(CH_3)(C_2H_5)S$, 259·66° ; $(C_5H_{11})HS$, isoamyl sulphhydrate, 334° (with reserve, on account of a slight decomposition), or by Pawlewski's method of mixtures (with ether), 330·92° ; isoamylic sulphide $(C_5H_{11})_2S$, 391·25° by method of mixtures ; $(C_3H_5)_2S$, 380·38° ; $(C_2H_5)_2S_2$, 368·93°. The ratio between the critical temperature and the boiling-point at 1 atmosphere, in degrees absolute, is about 1·55 in all these cases. A. D.

625. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Comptes Rendus, 131. pp. 1200–1202, Dec. 24, 1900.)—The author summarises the inferences which can be drawn from the form of the isothermals of the groups of gaseous mixtures previously obtained by him. (See Comptes Rendus, Jan. 22 and Mar. 26, 1900). For a point moving along the *line of ebullition*, the excess of the inclination to the axis of the tangent to the isothermal for the homogeneous condition over that of the tangent to the isothermal for the mixed condition commences by being positive. As the point approaches the critical point, this excess diminishes, vanishing at the critical point ; it then becomes nega-

tive, diminishes to a minimum, and then increases, reaching zero again at the point of contact of the limiting isothermal, becoming positive and continually increasing as the moving point descends along the *dew-point* line. These experimental results entirely agree with the hypotheses and deductions of Duhem. [See further Abstracts Nos. 2004 and 843 (1900).] W. E. T.

626. *The Characteristic of Water.* **A. D. Risteen.** (Amer. Phys. Soc., Bull. 1. p. 63, 1900.)—Amagat's measures from 1 to 1,000 atmospheres and from 0° to 100° C. are very closely represented by—

$$p = \alpha(T)/(v - \lambda) - \beta(T),$$

where—

$$\alpha(T) = 1363{\cdot}1 + 3{\cdot}126T - 36292/(T - 210)$$
$$\beta(T) = 14870{\cdot}3 - 14{\cdot}565T - 479360/(T - 182)$$
$$\lambda = 0{\cdot}7085,$$

p being measured in atmospheres, T being absolute temperature, and the volume-unit being that of water at 0° C. under 1 atmosphere. R. E. B.

627. *Surface-heating.* **L. Holborn** and **W. Dittenberger.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1724–1727, Dec. 15, 1900. Communicated by the Physikalisch-Technische Reichsanstalt.)—This is an investigation of the calorific transition-resistance between a metal and *boiling* water. The drop Δ in temperature from the inner surface, of radius r_0, of a cylindrical vessel of red brass, immersed in hot paraffin or palmin, to water kept boiling within it by the heat transmitted through its walls is calculated from thermoelectric measures of the differences in temperature S′ and S between two points in the solid walls at distances r_2 and r_1 from the axis and between the latter point and the water respectively; for—

$$\Delta = S - S' \log (r_1/r_0)/\log (r_2/r_1),$$

and the flow of heat Q through the inner surface is—

$$Q = KS'/r_0 \log (r_2/r_1),$$

if K is the conductivity. From four different series of experiments, 82 in all, with $K = 0{\cdot}169$, the author finds—

$$\Delta = 0{\cdot}782 + 3{\cdot}69Q,$$

so that the transition-resistance $R \equiv \Delta/Q$ is thus equivalent to the resistance of a thickness of iron (of conductivity 0·145) equal to—

$$0{\cdot}145R = 0{\cdot}534 + 0{\cdot}113/Q = 0{\cdot}534 + 7{\cdot}59/P \text{ cm.},$$

where P is the number of kilos of steam generated per square metre per hour (since $P/Q = 36{,}000/536$). This holds for values of Q between 0·07 and 0·6 or for values of P between 4·7 and 40.

When the water is made to boil by the passage into it of steam, and the heat travels outwards, a series of twenty-six experiments shows the transition-resistance R (and not Δ) to be a linear function of Q and to be equivalent to the resistance of a thickness

$$0{\cdot}458 + 1{\cdot}91Q = 0{\cdot}458 + 0{\cdot}028P \text{ cm.}$$

of iron.

R. E. B.

ELECTRICITY AND MAGNETISM.

628. *Atmospheric Electricity and Actinic Power of Sunlight.* **H. Mache.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 656–694, June and July, 1900.)—Observations tabulated, of sunlight in the Indian Ocean at different heights of the sun, sunlight and atmospheric potential slope at Delhi, sunlight in Ceylon and the atmospheric potential slope at Luxor. For the first the actinic power was found greater when the sun was high than any of the usual formulæ show. At Delhi the mean values of the potential slope and the water-vapour pressure were 127 and 3·5, which is not in accord with previous results; and evidence was obtained of a daily maximum of potential slope; the average potential slope was too small, being 36 for a water-vapour pressure of 8·3. The afternoon actinism was always less than that at the corresponding time in the forenoon. In Ceylon the reverse was the case. A. D.

629. *Electric Dispersion in Free Atmosphere at different Places.* **J. Elster.** (Phys. Zeitschr. 2. pp. 113–116, Nov. 24, 1900.)—The author describes tests made in 1900 from Bincra and Algiers to the North Cape. There is an increase of the dispersion-coefficient at mountain heights. There is also a great difference between continental and oceanic climates, as if the air were positively ionised by breaking waves; and this is the better marked the further north the station, negative charges being lost more rapidly than positive. The absolute values of the coefficient, apart from the signs of the charges, do not seem to depend much on the latitude. The values of the coefficient fall as the moisture increases, even before there is any visible formation of water-drops. A. D.

630. *Telluric Electricity.* **C. Liebenow.** (Elektrotechn. Zeitschr. 21. pp. 962–966, Nov. 15, 1900. Paper read before the Elektrotechn. Verein.)—This paper deals with atmospheric electricity, thunderstorms, and polar lights. Le Cadet observed in balloon ascents a p.d. of 36·5 volts per metre at an altitude of 1420 m., and of 13·4 volts per metre at an altitude of 4015 m. Assuming those figures to be substantially correct, Liebenow calculates that the whole surface of the earth would bear a negative charge of 300,000 coulombs, 2 electrostatic units per sq. m. The same quantity of positive electricity would be in the air under a serene sky, and an air cube of 10 m. edge would contain 0·65 units near the earth surface, and only 0·02 of this quantity at an altitude of 10,000 m. The p. d. between the earth surface and universal space would be —164,000 volts. If this electrification were due to ionisation (Elster and Geitel) caused by radiation, then the electrification should be reduced to half its value within an hour after sunset, and to ¼ per cent. in ten hours, and should disappear, therefore, during a long night. But we have electric maxima and minima during the night as well as during the day. Ascending heat currents, however, would carry positive electricity to the upper strata, and the author calculates that these currents would account for the p.d. observed.

A drop of rain in the clouds will assume a positive or negative charge, according as it is colder or warmer than the surrounding air. When the ascending air cools, the drops will, for a while, keep their higher temperature

and become negatively charged within a positive shell of air ; the cloud as a whole will not appear electrified. When the drops increase in size, they will no longer float with the air from which they were condensed, but lag behind; thus the cloud will become positive above and negative below. Our electric instruments will not be affected, until a wind has separated the lighter positively charged portions from the negative. The falling drops may come into warmer strata again and change their polarity. A difference of 1° C. between the globules and the ambient air would suffice to produce a quantity of 3 coulombs in a sphere of 300 m. radius with a p.d. of 100 million volts. We know little about the energy of lightning-flashes. But Humphrey's observations on the influence of spark length exercised by small negative discharges should modify our views. The above figures would involve considerable energy, in any case, and that energy would not be derived from the thermo-currents, but from gravity, which causes the raindrops to descend. It is noteworthy that no allusion is made to rainless thunderstorms.

The polar lights would be due to brush discharges between ice needles (often seen to fall after polar light displays), which play the part of the raindrops. Such discharges are started by winds, and occasionally by radiations from sunspots, which the author regards as breaks in the metallic vapour envelope around the incandescent gas sphere. Polar lights sometimes—not always—affect the magnetic needle. Paulsen and Vedel observed in Greenland—*i.e.*, E. of the magnetic pole—that polar lights, apparently of low altitude, deflected the needle to the W. when they were approaching from the S., and to the E. when they had passed over them to the N. in their usual course. The opposite applies to Point Barrow, W. of the pole, and the rule for this deflection by polar lights in motion was already recognised by John Franklin in 1820. The deflection cannot be due to electrostatic charges. It is caused by the electric currents, circulating in ascending atmospheric currents of thermal character, when rendered conducting through ionisation by radiations. The magnetic needle moves owing to induction, resulting when these ascending currents cut the terrestrial magnetic lines of force. This view would also explain the diurnal variation in the magnetic elements.

H. B.

DISCHARGE AND OSCILLATIONS.

631. *Inconstancy of Spark Potential.* **K. R. Johnson.** (Ann. d. Physik, 3. 3. pp. 461–470, Nov., 1900.)—This paper supports Jaumann's of 1895, which has since been much discussed in the *Annalen*, and which asserts, among other things, the presence of oscillations during the charging of a Leyden jar by means of an influence machine. This latter having been contradicted by Precht (1898), Johnson holds that Faraday proved it long ago by electrolysing water by a statical machine, and showing that H and O are given off at both electrodes. Johnson has carried out the electrolysis, using one electrode only; and he supports Heydweiller on the point that the capacity of the Leyden jar does not influence the sparking potential. But he shows, by a mathematical example, that the expected damping of dE/dT is not confirmed, and deduces that the potential undergoes oscillatory changes which can explain, for example, the above electrolytic experiment. The case is also considered where the sparking potential is very large compared with the variation of potential at the spark micrometer ball, and the equation, $E = a + b\lambda$, connecting sparking potential (E) with length of spark-gap (λ) is again deduced.

G. E. A.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

632. *Volta Effect.* **Q. Maiorana.** (N. Cimento, 12. pp. 196–207, Sept.–Oct. 1900. Accad. Lincei, Atti, Aug. 19, and Sept. 2, and 16, 1900.)—Discussion of the contact theory and the chemical theory, and an experimental investigation. The method of measurement is by bringing the two metals to an equal potential, so that a charged silvered quartz filament is not attracted towards either. Low temperatures do not alter the order of the voltaic series, but so far reduce the volta effect that it would appear that at absolute zero there could be no such effect; for example, Zn/Au gives 0·88 volt in the atmosphere, 0·05 on dropping liquid air on; Al/Au similarly, 1·05 and 0·09; Fe/Au, 0·41 and a non-measurable result. When the original temperature is regained the original voltage is not recovered—*e.g.*, after one hour we have Zn/Au 0·73 only, Al/Au 0·82, and Fe/Au 0·25; as if the surface condition had altered. Measurements are given of the attraction between discs of different metals, by a balance and interference-fringes method, the fringes travelling as the discs slowly move towards one another. The mathematics of the method, including a null-method which eliminates the effect of Newtonian attraction, are also discussed. A. D.

633. *Deformation of Condensers.* **M. Cantone** and **F. Sozzani.** (N. Cimento, 12. pp. 155–164, Sept.–Oct., 1900; more fully in Rendic. dell' Istituto Lomb. 33. p. 1059, 1900.)—Experimental determination of the constants. It appears that the dielectric constant increases appreciably with increase of pressure. A. D.

634. *Coherers and Sound-Waves.* **E. Drago.** (N. Cimento, 12. pp. 191–195, Sept.–Oct., 1900: Atti Acc. Gioenia di Catania, vol. 13. ser. 4.)—Upon the formation of Chladni figures on vibrating plates with fine carbon powder, the electric resistance is greatly reduced; in some cases a minimum is reached before the final condition is attained. The electric current passes along each nodal line. Raising the pitch of the sound generally increases the conductivity, the nodal lines being the most numerous. In ordinary coherers the diminution of resistance seems to be due to the transport of the powder from ventral to nodal regions, perhaps into such intimate contact that adhesive forces come to some extent into play. A. D.

635. *Electric Discharge in Closed Volumes of Air.* **H. Geitel.** (Phys. Zeitschr. 2. pp. 116–119, Nov. 24, 1900.)—The loss of electric charge is not proportional to the charge, but remains nearly constant between 80 and 240 volts. The conclusion of the paper is that for every given temperature and pressure of air there is a corresponding percentage of ions and a corresponding conductivity; and that when the percentage of ions is reduced by electric forces, ions are regenerated to restore equilibrium. Daylight and artificial light make no observable difference. A. D.

636. *Nernst Filaments.* **W. Nernst** and **W. Wild.** (Zeitschr. Elektrochem. 7. pp. 373–376, Dec. 20, 1900.)—This paper describes life and efficiency tests of Zirconia, Thoria, and Yttria filaments, but does not mention what differences there are in the behaviour of the three oxides. The filaments begin to conduct at temperatures varying from 500° to 700° C. The change of conductivity with temperature is as follows:—

Temperature C....	500°	700°	800°	900°	1,000°	1,100°
Conductivity ...	0·03	0·16	0·64	1·84	3·6	9·9

Figures are given of efficiencies at different currents for four sizes of filaments; one filament, 23 mm. long and 0·6 mm. diameter, gave 18·6 candles with 0·25 ampere, at an efficiency of 2·32 watts per candle, and 227 candles with 0·8 ampere at an efficiency of 0·61 watts per candle. As an example of a life test, a filament running at an efficiency of 1·27 watts per candle and 184 volts, after 522 hours, had an efficiency of 1·50 watts per candle, but was not burnt out. G. H. B.

637. *Portable Apparatus for Testing Cables.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 22. pp. 79–80, Jan. 24, 1901.)—This apparatus comprises an ebonite slab on which are mounted the necessary terminals, resistances, condenser, plug-switches, keys, &c., for measuring (*a*) the insulation resistance, (*b*) the capacity, and (*c*) the resistance of the conductor, of a cable. There are three terminals to which the ends of the cable and the earth are respectively connected, these terminals being mounted on bars which can be connected by plugs to blocks joined up to the several sets of testing apparatus, *e.g.*, the galvanometer and standard resistance (10,000 ohms) for the (*a*) test; to the ballistic galvanometer and standard condenser (0·5 microfarad) for the (*b*) test; and to a dial-pattern bridge for the (*c*) test. This bridge has centrally pivoted contact arms instead of plugs. A set of shunts for the galvanometer can also be mounted on the board. A photograph of the apparatus and a series of diagrams, showing the connections for the several tests, are given in the original paper. C. K. F.

638. *Sticking of Relay with Condenser Shunt.* **W. O. Pennell.** (Elect. World and Engineer, 36. p. 808, Nov. 24, 1900.)—The author found that the contacts of a closely adjusted relay when bridged by a condenser had a tendency to stick, and he has investigated the cause of this. He attributes the effect to charges, produced by the condenser, collecting at the contact points, and exercising an attractive action. It may be avoided by introducing resistance into the condenser circuit. G. H. B.

639. *Potentiometer.* **N. T. M. Wilsmore.** (Elektrotechn. Zeitschr. 21. pp. 997–998, Nov. 29, 1900.)—Two series of sixteen coils, of a total resistance of 10,000 ohms each, have their contact pieces arranged in two parallel rows, so that each coil in one row is opposite a coil of equal value in the other. The coils are in series of 1, 1, 2, 5. On a central axis, between and parallel to the two rows of contacts, are sixteen two-way switches, which short-circuit either one or the other of two opposite coils. Half the total resistance of 20,000 ohms is always short-circuited by these switches, and the 10,000 ohms always in circuit can be distributed between the two rows as desired. One row is marked in ohms and the other in volts, 1 volt being made equivalent to 5,000 ohms; the bridge is then direct reading, when a potential of 2 volts is maintained on the two rows in series, and the unknown potential is connected in series with a galvanometer to the row marked in volts. The bridge is standardised as usual by a standard cell connected in place of the unknown potential. Higher potentials may be employed, but the bridge is then not direct reading. G. H. B.

640. *Ammeter and Voltmeter with Adjustable Field.* **Menges.** (Soc. Franç. Phys., Bull. 155. p. 2, 1900.)—The instrument is of the d'Arsonval type, and the permanent magnet is provided with an iron piece, acting as a magnetic shunt, the position of which can be adjusted by a screw. The iron core,

between the poles of the magnet, is capable of a slight eccentric motion about a horizontal axis, so that the attractions of gravity and of the magnet tend to move it in opposite directions. The magnetic shunt is adjusted until these two attractions are in equilibrium—a condition which corresponds to a definite strength of field in the air-gap. With a variation of 30 per cent. in the strength of the magnet, the strength of the field can in this way be adjusted to within 1 per cent. G. H. B.

641. *Ebert-Hoffmann Electrostatic Voltmeter.* **C. Bäumler.** (Elektrotechn. Zeitschr. 21. pp. 1015–1016, Dec. 6, 1900.)—The voltmeter consists of an aluminium ellipsoid suspended between two parallel metal discs, fixed in vertical planes. The deflections are read by a mirror and scale. The zero point is at a position in which the major axis of the ellipsoid is at an angle of 45° with the normal to the discs. The oscillations of the ellipsoid are damped by the action of a magnetic field on a copper cylinder fixed below the ellipsoid. The ellipsoid is suspended by a bifilar suspension from a torsion head, which affords a zero adjustment. The distance between the upper ends of the two fibres of the suspension can be varied by the insertion of distance pieces provided with the instrument. The discs also can be fixed at different distances, one from the other. Their diameter is 270 mm., the major axis of the ellipsoid is 29 mm. With the discs separated by 26·5 mm., 3,000 volts gave a deflection of 100 mm. at 1 m. distance. The constant was found to diminish with increase of pressure; between 2,000 and 10,000 volts, there was a variation of 3½ per cent. in the constant. G. H. B.

642. *Ebert-Hoffmann Electrostatic Voltmeter.* **A. Schwartz.** (Elektrotechn. Zeitschr. 21. pp. 1076–1077, Dec. 20, 1900.)—The author refers to the tests on this voltmeter made by Bäumler [see preceding Abstract], in which the constant was found to diminish regularly with increase of deflection. His own experiments, however, show no regular variation in the constant, which throughout his measurements does not vary more than 1 per cent. from its mean value. He finds also that the constant is directly proportional to the distance between the discs. G. H. B.

643. *Calibration of Resistance Bridges.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. pp. 912–913, Nov. 1, 1900.)—This article describes the calibration of a plug resistance bridge against a standard ohm. The author recommends the substitution of a resistance of thick manganin wire for the copper piece connecting the bridge resistance with the ratio arm, so as to bring the resistance of the plug-contacts to a definite value, such as 0·005 ohm; a balancing resistance can then be added to the standard ohm, when making exact comparisons. The comparison of the bridge ratios is greatly facilitated in the bridges constructed by the author, in which the connections of the ratio arms can be reversed. [See following Abstract.] G. H. B.

644. *Resistance Bridges with Reversible Ratios.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. pp. 979–980, Nov. 22, 1900.)—This article describes, with seven illustrations, four different types of resistance bridges, designed by the author, with connections enabling the two ratio arms to be interchanged [see preceding Abstract]. In the P.O. type of bridge the two ratio arms are parallel to each other, each with plug connections at either end to the ends of a brass piece running between them; the

bridge terminal at one end, and the connection to the bridge resistance at the other end of the ratio arms, can be connected to either arm by a plug. In the plug-dial and switch-dial types, a pair of terminals, with plug-connection between, is fixed at each end of the two ratio arms, which are permanently connected in series. The unknown resistance is connected to one pair, and the other carries an ebonite piece with the galvanometer and battery keys and terminals, with cord connections to the bridge. Interchanging this with the unknown resistance reverses the ratio arms. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

645. *Viscous Hysteresis.* **K. Krogh** and **H. Rikli.** (Elektrotechn. Zeitschr. 21. pp. 1083–1086, Dec. 27, 1900.)—Two rings were used by the authors in their experiments; most of the measurements were carried out with the first ring, which contained 7·792 kg. of iron, and was built up of discs 0·3 mm. thick, having an external diameter of 20·2 cm., and an internal one of 13 cm. The second ring was used only for checking the results obtained with the first, and consisted of discs 0·19 mm. thick. The total power absorbed by the iron was measured by a reflecting wattmeter. Curves were constructed connecting the total iron loss with the frequency for a *given constant value of the induction.* The eddy-current loss for each frequency was then calculated by means of Steinmetz's formula, and was subtracted from the total loss. The difference gave the hysteresis loss. The inductions used were 5,000, 10,000, and 15,000. In each case it was found that for a given induction the hysteresis loss per cubic cm. per cycle increased with the frequency, and the percentage increase was greater for higher values of the induction. Thus, at 50 cycles per sec. the loss was 10 per cent. greater for B = 5,000, and 30 per cent. greater for B = 15,000, than the loss corresponding to the static hysteresis loop. The authors next investigated the effect of wave-form, and found that *for a given maximum induction,* a peaked e.m.f. wave (and therefore a flat-topped induction wave) corresponded to a higher hysteresis loss. They remark in this connection that the result might have been anticipated, since with a flat-topped induction wave the changes in the induction are more rapid—except, of course, near the maximum points. Curves of p.d. and current were next determined, and from them the values of the permeability were deduced. The latter was found to decrease steadily, for a given maximum B, as the frequency increased. A. H.

646. *Residual Magnetism.* **P. Holitscher.** (Ann. d. Physik, 3. 4. pp. 683–719, Dec., 1900.)—The author's experiments were confined to a single ellipsoid of Jura iron, having axes 36 cm. and 0·288 cm. The method of measurement adopted was the magnetometric, with a magnetising coil 60 cm. in length. The results of the experiments are as follows: The residual magnetic moment reaches a maximum value only after magnetising for a certain time, from 1′ 15″ for H = 0·99 to 2′ 30″ for H = 3·6 or over. Repeated magnetisations, if in one direction only, give continually increasing residual moments; after 100 magnetisations, beyond which the author did not go, the residual moment was still on the increase. On the other hand, if the successive magnetisations are alternately in each direction, the maximum residual moment is acquired after the first or second; the maximum so reached is about 12 per cent. lower than that when the iron is magnetised in one direction only.

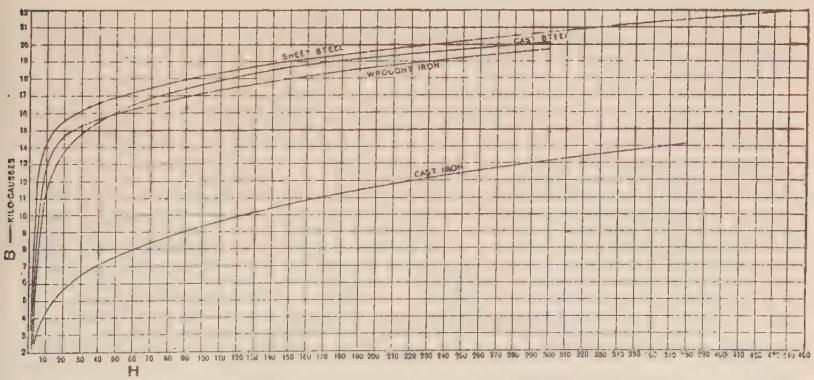
The magnetic moment due to the magnetisation is not affected, either by the duration of magnetisation [the author did not deal with very short periods], or by the number of magnetisations. The residual moment is somewhat smaller, if the magnetising force be removed suddenly, than if it be removed gradually, or by steps of not more than 3 per cent.; but a sudden and a gradual magnetisation has the same effect. Contrary to the generally accepted results, the author finds that a small value of H, amounting to 0·055, produces a residual magnetic moment equal to 6 per cent. of the "temporary" moment. The ratio of the residual to the temporary magnetism rises very rapidly from 35 per cent. for H = 0·6 to 70 per cent. for H = 0·72, and then descends to a constant value of 41 per cent. for H = 6·0.

In making the experiments, the iron was demagnetised after each reading; if this be not done, the maximum ratio is only 61 per cent. for H = 0·9.

Measurements of the hysteresis loss were made, and curves are given between the various quantities. The exponent of B in Steinmetz's law varied from 1·21 for B = 11,800 to 2·64 for B = 22. The author finally explains his results in the light of Wiedemann's molecular theory, assuming the existence of frictional or cohesion forces between the molecular magnets.

G. H. B.

647. *Tests of American Iron and Steel.* **J. W. Esterline** and **R. B. Treat.** (Elect. World and Engineer, 36. pp. 959–960, Dec. 22, 1900.)—These tests were made on more than one hundred samples received from twenty of



the chief electrical manufacturing companies. The curves show the results for the best sample of each kind of metal. The poorest piece of sheet iron gave B = 9,900, 14,850, and 18,800, when H was 10, 100, and 450 respectively.

W. H. E.

648. *Lines of Induction in a Magnetic Field.* **H. S. Hele-Shaw** and **A. Hay.** (Roy. Soc., Phil. Trans. 195. pp. 303–327, Dec. 20, 1900; Roy. Soc., Proc. 67. pp. 234–236, Nov. 14, 1900 (Abstract).)—Stokes having shown theoretically and Hele-Shaw by experiment that the stream lines of a viscous liquid in a channel between two parallel planes near together, are identical with those of the two dimensional flow of a perfect liquid in the same channel [Abstract No. 978 (1899)], the authors now show that the stream lines found by experiment when the distance between the parallel planes varies, are identical with the lines of induction through media which differ

in permeability. They investigate the relation between the variations of thickness and permeability, both by experiment and by theory, and find the two in accord. The apparatus used enables photographs of the colour bands which represent the lines of induction to be taken, and the paper contains reproductions of a large number of photographs of interesting cases of induction in and around solid and hollow prisms and cylinders, and through pole-pieces and armatures of dynamos of various types. The latter cases furnish valuable information on a subject of great importance to designers of electrical machinery. W. G. R.

649. *Secular Variation of Terrestrial Magnetism.* **P. S. Wedell-Wedellsborg.** (Ann. d. Physik, 3. 3. pp. 540–542, Nov., 1900.)—The author maintains that Paulsen's theory gives a correct explanation of the secular variation. The rotation of the negatively charged earth should produce a magnetic system with its axis coincident with the axis of rotation. This is, however, disturbed by a system of currents in the form of two half-ring shaped solenoids lying always on the sunlit side of the earth and producing in the northern hemisphere during the day a west to east magnetic force, which, acting on the principal system, tends to cause a drift of its axis in accordance with observed facts. J. E.-M.

650. *Secular Variation of Terrestrial Magnetism at St. Petersburg-Pawlowsk.* **H. Wild.** (Acad. Sci. St. Pétersbourg, Mém. 9. pp. 1–40, 1900.)—From series of observations extending over the greater part of last century, the author concludes that the secular variation in St. Petersburg is not continuous, but is made up of many small irregularities, so that it is impossible to represent it with any exactitude by means of a formula. J. E.-M.

651. *Present State of the Theory of Terrestrial Magnetism.* **A. Nippoldt.** (Phys. Zeitschr. 2. pp. 108–110, Nov. 17 ; and 119–125, Nov. 24, 1900.)—Great progress has been made during the last fifteen years. The new epoch opens with Ad. Schmidt's theory of a constant magnetic potential which reverts to Gauss's original ideas. Superimposed upon this potential is a system of forces which produces the variations and which depends essentially upon thermal and electrical radiations from the sun. This system travels round the earth in a day ; it may have a potential and be a function of the geographical length. The researches of Rücker, Carlheim-Gyllenskiöld, Liznar, and L. A. Bauer, leave little doubt that the constant components are not due to vertical electric currents in the atmosphere. Liznar's analysis of the records of the Austrian observatories, which are situated at different altitudes, seems to indicate, however, that there may be magnetic forces outside the earth. The conception of normal potential (von Bezold and Bauer) points to the existence of three pairs of poles, south poles in Africa, south of Australia, and south of the Aleutian Islands, and north poles in China, Southern Georgia, and North America. The constant magnetism may itself decrease or increase owing to losses of energy from the earth or movements of the solar system in space ; it seems to shift on the globe. According to Gyllenskiöld, the chief magnetic axis describes a cone of 23° 28′ about the rotation axis in 3147 years. This view would be compatible with the assumption of a magnetic sphere revolving in an electric field (Hertz) in the atmosphere, the field itself revolving in the opposite direction. We have no proof of the existence of such a field, but the view receives independent support by Schuster, A. Korn, and Wessely. The daily variations are certainly connected with meteorological conditions

(Bezold and Schuster). The influence of the sunspots period seems established (W. Ellis), not that of the sun rotation (26 days). Most magnetic disturbances become more marked in higher latitudes (Lüdeling). H. B.

652. *Magnetic Observations during an Eclipse of the Sun.* **L. A. Bauer.** (Amer. Phys. Soc., Bull. 1. p. 64, 1900.)—Simultaneous readings of declination were made at six stations, three inside and three outside the belt of totality, covering an area from Alabama to Maryland. The horizontal force was also determined by a torsion unifilar at one station within the belt. The author states that all the stations show a magnetic effect which cannot be referred to any other cause than that of the eclipse, the principal effect occurring, like the fall in temperature, some minutes after totality. The effect produced is as though part of the night hours were interposed among the day hours. Thus, in the case of the declination, which had passed the morning elongation, there was an increase of about 20″ to 40″, if the declination be east, and a decrease if the declination be west. The horizontal force, which at the time was approaching its minimum value for the day, was increased.

W. W.

REFERENCES.

653. *Universal Shunt.* **Tuch.** (Archiv. Post Tele. 24. pp. 925–933, Dec., 1900.) —A description is given of the Ayrton and Mather shunt for galvanometers, and of the particular form of it adopted by the German Imperial Post Office. R. A.

654. *Measurement of Insulation Resistance of Cables.* **J. Rabinowicz.** (Elektrotechn. Zeitschr. 22. pp. 98–99, Jan. 31, 1901.)—The author states that for comparing the insulation resistances of short lengths (say 1 yard) of cable, he has found Bright and Clark's accumulation method extremely useful. A diagram of the necessary connections is given. A. H.

655. *Evaluation of Mutual Potential.* **E. Mathy.** (Journ. de Physique, 10. pp. 33–36, Jan., 1901.)—A mathematical note explaining a method of obtaining in the form of a rapidly converging series the value of the mutual potential of two parallel circular circuits carrying electric currents. E. H. B.

656. *Photoelectric Sensitiveness of Ice.* **H. Benndorf.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 695–698, 1900.)- The author denies Brillouin's statement [Abstract No. 1835 (1900)] that ice has any photoelectric sensitiveness, and rejects the theory of atmospheric electricity based upon this alleged property. A. D.

657. *The Vortex Theory of Atoms as Applied to Electrolysis and Kathode Rays.* **M. Frank.** (Elektrochem. Zeitschr. 7. pp 184–188, Nov., 1900.)—A discussion of electrolytic phenomena, Faraday's law of constant electrochemical equivalent, &c., on the vortex theory of atoms, with suggested explanations of Lenard's experiments, Boyle's law, and the behaviour of gases under compression. D. E. J.

658. *Pressure and Temperature in Electric Sparks.* **E. Haschek.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 866–877, 1900.)—A mathematical discussion of the relation of temperature and pressure along the line of electrical discharge in reference specially to the experimental work of Schuster. E. H. B.

659. *Terrestrial Magnetism in Obdorsk and Ssamarowo.* **H. Abels.** (Acad. Sci. St. Pétersbourg, Bull. 11. pp. 9–27, 1899.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

660. *Reaction Velocity and Equilibrium.* **W. D. Bancroft.** (Journ. Phys. Chem. 4. pp. 705–708, Dec., 1900.)—The author considers the equilibrium between ammonium carbonate and its dissociation products, all in the gaseous state, assuming (1) that the reaction takes place in one stage according to the equation—

$$2NH_3 + CO_2 \rightleftarrows NH_4CO_2NH_2,$$

and (2) that there are two stages to the action, represented by the equations—

$$(a)\ NH_3 + CO_2 \rightleftarrows NH_2.CO_2H$$

and—

$$(b)\ NH_3 + NH_2CO_2H \rightleftarrows NH_4CO_2NH_2.$$

In the first case the equilibrium equation is—

$$Kx = (A - x)^2(B - x),$$

and in the second—

$$Kx = (A - x - y/2)^2(B - x - y);$$

where 2A and B represent the initial concentrations of NH_3 and CO_2 respectively, and x and y the concentrations at any moment of $NH_4CO_2NH_2$ and NH_2CO_2H. If y is zero, *i.e.*, if the NH_2CO_2H is used up as fast as formed, the reaction would be of the second order if the reaction velocity alone were studied, although the chemical equation would call for a reaction of the third order. It is therefore clear that abnormal reaction velocities may, and probably do, occur in the case of reversible reactions, despite the fact that irreversibility is often postulated as requisite to an abnormal reaction.

T. H. P.

661. *Chemical Equilibrium.* **O. Boudouard.** (Comptes Rendus, 131. pp. 1204–1206, Dec. 24, 1900.)—In continuation of his previous experiments [see Abstract No. 673 (1900)], the author verifies for different pressures the general law of the equilibrium of gaseous systems. He studies the action of carbon dioxide, diluted with nitrogen, on carbon, verifying the formula due to Le Chatelier, and finding that the rate at which the reaction occurs is lessened by diminution of pressure in confirmation of the law enunciated by Le Chatelier (Comptes Rendus, 128. p. 1524). The above formula determines the composition of the gaseous mixtures resulting from the action of air on carbon at different temperatures, and a table is given accordingly.

W. E. T.

662. *Evolution of Heat on Wetting Powders.* **M. Bellati.** (N. Cimento, 12. pp. 296–300, Nov.–Dec., 1900. From the Atti del R. Istituto Veneto. T. 59. pp. 931–947, 1900.)—The author discusses the two theories put forward to explain the development of heat when a powder is moistened with water. According to the first, an enormous compression occurs in the stratum of liquid in contact with the surface of the solid, this being supported by the experiments of Bunsen showing that a very thin film of water remains on the surface of glass even at very high temperatures, and that carbon dioxide is extremely soluble in such a film. On moistening sand with water, Jungk found that below 4° an absorption of heat occurred, whilst

Meissner obtained heat development even at 0°. The author describes experiments made on the moistening of fine river sand with water, the changes of temperature being measured by means of a thermoelectric pile connected with a galvanometer. The cooling observed by Jungk is not noticed, and when the sand employed was previously dried by gentle heating, the change of temperature is in all cases several tenths of a degree. Heating is also obtained, although to a less extent, when sand containing less than 1·4 or more than 2·1 per cent. of water is moistened with its own weight of water; when the content of water lies between 1·4 and 2·1, the results are inconclusive, in some cases cooling and in others heating taking place. Any cooling which does take place at temperatures below 4° with suitably moist powders is very slight, and the observations of Jungk must be regarded as inaccurate.

The second hypothesis, originated by Cantoni and expanded by Martini, supposes that the moistening of such powders (which are described as "hygrophile" owing to the fact that they absorb a certain amount of water without losing their pulverulent character) is in some respects analogous with the phenomenon of solution, the evolution of heat observed being due to the solidification of part of the water absorbed by the powder. Martini's measurements of the specific heat of such absorbed water gave a value of about 0·5; that is, the same as for ice and for the water of hydrated salts. On repeating these determinations by a more delicate and direct method, the author obtains for the specific heat of the absorbed water values differing but slightly from unity.

It is probable that the heat evolved when a powder is moistened with a liquid is the net result of the replacement of the free surface of the solid by a solid-liquid surface of contact and the addition of a liquid-air surface.

T. H. P.

663. *Chemical Compounds in Alloys.* **F. H. Neville.** (Brit. Assoc. Report (1900), pp. 131–149.)—This paper contains a description of the various methods employed for the detection of "intermetallic" chemical compounds, which are classified as follows: (1) Chemical methods, such as extracting the pure compound from an alloy by filtration, by volatilisation of excess of a volatile metal or by removing the excess of metal by means of a suitable solvent. (2) A study of the chemical equilibrium of the mixed metals, most conveniently by the freezing-point curve. (3) Microscopic examination of the polished surface of the solidified mixture, after etching or oxidation. (4) Röntgen-ray photography. (5) The determination of the difference of electrical potential existing between a metal and its alloys. (6) Measurement of heat by formation, and (7) of the electrical conductivity. The results obtained by each of these methods are described in detail. The second part of the paper contains a list of the intermetallic compounds at present known, together with the evidence on which the formula of each is based and the name of the investigator. The results are also given of the work of the author and Heycock on the depression of freezing-point of the metals tin, zinc, bismuth, cadmium, and lead, caused by the solution of small quantities of other metals.

T. H. P.

664. *Crystalline Structure of Metals.* **J. A. Ewing** and **W. Rosenhain.** (Roy. Soc., Phil. Trans. 195. pp. 279–301, Dec. 10, 1900; and Roy. Soc., Proc. 67. pp. 112–117, Oct. 26, 1900 (Abstract).)—This is the second paper by the authors on the same subject [see Abstracts Nos. 1196 (1899) and 1133 (1900)]. Attempts made to watch the alteration in structure by means of a microscope

during the heating of specimens failed ; but by marking off a portion of the polished and etched surface, the structure of a specimen before and after the required treatment was examined under practically identical conditions, the surface being repolished and etched prior to each fresh examination. No satisfactory results have yet been obtained with iron, but it is shown that lead that has been rolled or subjected to severe mechanical stress gradually becomes more largely crystalline even at ordinary temperatures, the rapidity of the change increasing as the temperature rises ; even at 200° C. a great alteration is produced in less than half an hour. Cast lead, unstrained, does not show these structural changes in the same way. Quenching at 200° or 300° C., even in liquid air, is without visible effect on the structure. No "arrest" point, similar to the "Ar" points of cooling iron, could be observed in the thermal (time-temperature) curve of cooling lead. In the case of pressure-welds of clean lead surfaces, although the crystalline structure altered on either side of the weld-line, in no case was a crystal observed to grow across the weld, unless flakes of a eutectic alloy of lead and bismuth (or other metal of low fusing-point) were sprinkled over the surface before making the weld. A complete layer of eutectic material had not the same effect, nor had particles of foreign matter such as sand or iron. This, taken with other observations—as, for example, the growth of certain individual crystals at the expense of others—has led to the evolution of the theory that the recrystallisation is due to the solution and diffusion of the pure metal-crystals into the eutectic film around them, and to the deposition of the metal on other crystals, the action probably being electrolytic and depending upon the presence of two crystals of unlike solution-pressure in contact at one part but separated otherwise by a film of eutectic alloy. This would explain the non-recrystallisation of cast metal (in which, it may be supposed, each metal-crystal is entirely surrounded and isolated from its neighbours by a thin film of eutectic, resulting from the presence of impurities) until the structure should have been broken down mechanically and adjacent crystals should have been in many cases pressed into contact. Tin, zinc, and cadmium each show the same tendency as lead to recrystallise after rolling. Photographs are given showing the changes described. W. G. M.

665. *Formation of Syngenite.* **J. H. van't Hoff** and **H. A. Wilson.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 53. pp. 1142–1149, Dec. 20, 1900.)—This is one of a series of papers [see Abstracts Nos. 226, 1114, 1116, 1879 (1900) and 528 (1901)] dealing with the theory of the formation of oceanic salt deposits, and more especially of the Stassfurt deposits. The conditions governing the formation and existence of syngenite—$CaK_2(SO_4)_2H_2O$—in solutions saturated with sodium chloride and the sulphates of sodium, potassium, and calcium at 25° have now been determined, and experiments have also been made with a view to the solution of the similar, but more complex, problem when magnesium salts are also present. Diagrams illustrating the results are given in the paper. N. L.

666. *Chemical Action of Rarefied Gases.* **A. Colson.** (Comptes Rendus, 131. pp. 1202–1204, Dec. 24, 1900.)—The author describes experiments which show that, apart from any electric or luminous stimulus, glass emits reducing gases, which are continually given off in presence of an absorbent, as though having a fixed pressure, and whose reducing power exceeds that of free hydrogen. Tubes were prepared, some containing red oxide and others yellow oxide of mercury ; some of each were filled with hydrogen and

others exhausted to a vacuum of $\frac{1}{3000000}$. After exposure to light for some months distinct reduction of the oxides was obtained, and analysis showed that much more oxide was reduced than corresponded to disappearance of hydrogen in the one case or to reappearance of oxygen in the other. Similar results were obtained with a tube full of oxygen. In analogous tubes kept in the dark for the same time similar effects were produced, but to a much less extent. The author is investigating whether this effect is due to the chemical composition of the glass or to the passage of hydrogen through the glass, or to an increase in the activity of hydrogen corresponding to that of fluorine in the presence of hydrochloric acid or water. W. E. T

667. *Solvent Action of Vapours.* **A. T. Lincoln.** (Journ. Phys. Chem. 4. pp. 715–731, Dec., 1900.)—Vapour pressure curves were plotted for salicylic acid between 82° and 157°, and for benzoic acid between 71° and 193°, and experiments were then made to ascertain whether, in presence of other vapours, the partial pressures of the volatile acids ever exceeded their normal vapour pressures, the method being to analyse the distillate from a saturated solution in water, benzene, or acetone. The results were all negative in character, as also were those obtained in the case of alcoholic solutions of naphthalene and of camphor.

Above the critical temperature the solvent action of vapours has been demonstrated by Hannay and Hogarth (Proc. Roy. Soc. 30. 178, 1880) in the case of KI, KBr, and $CaCl_2$ in alcohol-vapour, sulphur in CS_2, resin in light petroleum, $CoCl_2$ in alcohol, &c., and similar results have been obtained by Villard, Victet, and Wood. T. M. L.

668. *E.M.F. due to Magnetisation of an Electrode.* **R. Paillot.** (Comptes Rendus, 131. pp. 1194–1195, Dec. 24, 1900.)—If, in a cell composed of two iron electrodes dipping into acidulated water, one electrode be magnetised, it becomes positive to the non-magnetised electrode; and, according to the experiments of Hurmuzescu, who used fields up to 7,000 c.g.s. units, the curve expressing the relation between impressed magnetic field and resulting e.m.f. of magnetisation is similar to the curve of magnetisation of iron. The author now extends these experiments to very strong magnetic fields produced by an electromagnet of the Du Bois type, giving a field of more than 30,000 c.g.s. units. The electrodes dip into the liquid in the vertical arms of a flat U-tube whose horizontal arm is of such a length that when one electrode is fixed between the poles of the electromagnet, the other is in a field which is negligible.

The conclusion from all the experiments is that, for a given acid and specimen of iron, the e.m.f. of magnetisation always tends towards a fixed maximum, the value of which depends somewhat on the kind of iron and particular acid used. W. C. H.

669. *P.D. between Solutions.* **M. Couette.** (Journ. de. Physique, 9. pp. 652–655, Dec., 1900.)—A copper electrode was covered with a layer of normal copper sulphate, over which were layers of normal and deci-normal-sulphuric acid. A capillary electrometer showed a difference of −0·055 volt between the two layers of sulphuric acid, whilst Nernst's fomula gives −0·042. In a similar way the p.d. between normal and deci-normal zinc sulphate was found to be 0·006 volt, the calculated value being 0·010. T. M. L.

670. *Thermodynamics of the Hydrogen-Chlorine Gas Cell.* **I. Akunoff.** (Zeitschr. Elektrochem. 7. pp. 354–356, Dec. 6, 1900.)—The e.m.f. of a

hydrogen-chlorine gas cell is 1·37125 volts at 0°, 1·35685 volts at 18°, and 1·34221 volts at 36°. The heat of the reaction, as given by Helmholtz's formula, $q = E + T\frac{dE}{dT}$, is therefore 31,357 + 5,750 = 37,107 cal. This corresponds very closely with the value for the formation of HCl aq. from H_2 and Cl_2, which gives 39,300 cal., or allowing for the heat of dilution of the 3N solution used in the gas battery, 37,680 cal. The conclusion is drawn that the primary reaction which takes place in the battery is that represented by the equation $H_2 + Cl_2 = 2HCl$, and not the electrolytic reduction of either oxygen or hypochlorous acid, which might conceivably be formed at the chlorine electrode as the first products of the action. T. M. L.

671. *Gas Polarisation in Lead Accumulators.* **W. Nernst** and **F. Dolezalek.** (Zeitschr. Elektrochem. 6. pp. 549–550, May 10, 1900.)—On electrolysing dilute sulphuric acid between platinum electrodes the evolution of gas begins at 1·7 volts and is vigorous at 1·9 volts; between lead electrodes, however, no gas is liberated at this voltage, but lead and lead peroxide are produced at 2 volts, and the evolution of gas only begins when there is no lead sulphate on the plate and at a pressure of 2·3 volts. This is explained on the supposition that the occlusion of gas by platinum renders it possible to liberate it at a much lower voltage with platinum electrodes than with lead electrodes which do not possess this property. On passing a small current through the systems

$$Pt \mid H_2SO_4 \mid PbSO_4 \mid Pt \text{ and } Pt \mid H_2SO_4 \mid PbSO_4 \mid Pb,$$

it was found that in the second case there was a potential difference of 1·92 volts between the lead kathode and a lead peroxide electrode immersed in the solution, but a potential difference of only 1·60 volts in the case of the platinum kathode of the first system; the lead sulphate was completely reduced in the second system, but in the first system it was not reduced until a higher current density was used. This result is regarded as supporting the view that a high voltage is required to liberate gas from the lead electrodes, and the influence of mercury salts in raising the e.m.f. of an accumulator is similarly explained as due to an increase in the difficulty with which gas-bubbles are liberated. T. M. L.

672. *Gas Polarisation in Lead Accumulators.* **Strasser** and **Gahl.** (Zeitschr. Elektrochem. 7. pp. 11–13, 1900.)—On comparing lead with antimony and with lead-antimony alloys, it was found that hydrogen is most readily liberated from pure antimony and least readily from pure lead kathodes. T. M. L.

673. *Dissociation in Colloidal Solutions.* **M. G. Levi.** (N. Cimento, 12. pp. 293–296, Nov.–Dec., 1900. From the Gazz. Chim. Ital. t. 30. II., 1900.)—In order to find whether any exact relation exists between the internal friction of a solvent and the mobility of the ions of a dissolved salt, the author measures (1) the electrical conductivity of potassium iodide in water and in solutions of gelatine, agar-agar and silicic acid; (2) the depression of the freezing-point of potassium chloride and iodide in water and in solutions containing silicic acid and gelatine; (3) the velocity of inversion of sugar by dilute hydrochloric acid both in water and in silicic acid solution. Although the colloidal solutions employed have very great internal friction—the agar-agar solution, indeed, being solid at the temperature of the experiments—it is

found that for each of the three series of measurements the same results are obtained with the colloidal as with the aqueous solutions. The author therefore concludes that dissociation in colloidal solutions takes place in the same manner and to the same extent as in aqueous solutions. The only way of explaining these results seems to be by means of the reticular theory of colloidal solutions, according to which the molecules of a colloid are connected after the fashion of a network, so that in an aqueous colloid the water, and with it the ions of any dissolved electrolyte, passes freely through the meshes. T. H. P.

674. *Osmosis of Liquids.* **G. Flusin.** (Comptes Rendus, 131. pp. 1308–1309, Dec. 31, 1900.)—As in the case of vulcanised rubber [see Abstract No. 1013 (1898)], the rate of osmosis of different liquids through a membrane of bladder is dependent on the quantity of the liquid which is absorbed by unit weight of the bladder. This is shown by the following table, which gives (1) the velocity of osmosis in cubic millimetres per sq. dcm. per hour at 12° through the membrane when one side is in contact with the liquid and the other with ethyl alcohol, and (2) the volume in c.c. of the liquid absorbed by 100 gms. of the membrane :—

	Osmosis.	Absorption.
Water	4,674	121·9
Methyl alcohol	1,748	28·7
Amyl alcohol	646	7·2
Amyl acetate	532	6·8
Chloroform	456	5·5
Benzene	266	5·0
Ether	0	3·2
Ethyl alcohol	—	3·0

T. M. L.

675. *The Exact Relation between Osmotic and Vapour Pressure.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 35. pp. 707–721, Dec. 31, 1900; also Phys. Rev. 12. pp. 84–99, Feb., 1901.)—The osmotic pressure of a solution being defined as the pressure experienced by the semipermeable septum between the solution and the solvent, it is here proved in two different ways that the true thermodynamic relation between the osmotic pressure P_1 and the vapour pressure p_1 of a solution at temperature t is given in general by—

$$\int_{p_1}^{p_0} v\,dp = \int_{p_1 - P_1}^{p_0} V\,dP,$$

where V, v are the specific volumes of the solvent and its vapour at temperature t and pressure P, p_0 being the vapour pressure of the solvent. Worthington having shown that the compressibility of a liquid is practically constant even for negative pressures, such as is in general the difference $p_1 - P_1$, this relation reduces to—

$$\int_{p_1}^{p_0} v\,dp = \Pi_1 V_0(1 + \tfrac{1}{2}k_0\Pi_1),$$

where—

$$\Pi_1 \equiv P_1 + p_0 - p_1$$

represents what is ordinarily taken as the osmotic pressure (*i.e.*, the total difference in pressure of the solution and solvent when each is under only its own vapour pressure), V_0 the specific volume of the solvent under the pressure p_0 at temperature t, and k_0 the compressibility.

It is also shown that in the general case the relation is complicated, as the osmotic pressure does not depend on temperature only, but also on the *state of compression* of the solution, so that the magnitudes that occur in the relation vary with the condition of the solution, and are not measurable for the solution once for all. R. E. B.

676. *Birotation of d-Glucose.* **Y. Osaka.** (Zeitschr. Phys. Chem. 35. pp. 661–706, Dec. 31, 1900.)—The changes of rotatory power which take place in aqueous solutions of most sugars obey the laws for a reaction of the first order. This is shown to be true in the case of the eight sugars tabulated below, and the velocity constants (at about 20°) have the following values :—

d-Fructose	0·096	*l*-Xylose	0·022
Rhamnose	0·039	*d*-Galactose	0·0102
l-Arabinose	0·031	Maltose.....	0·0072
Fucose	0·022	Milk-sugar	0·0046

From the observations of Cohen on the effect of d-glucose in diminishing the velocity of saponification of ethyl acetate by caustic soda, it is shown that *d*-glucose is a feeble acid, and that its dissociation constant is $\frac{55{\cdot}5}{0{\cdot}022}$ of that of water (55·5 = concentration of water in gramme molecules per litre); taking the value for water as $\frac{1{\cdot}3 \times 10^{-14}}{55{\cdot}5}$, the dissociation constant of glucose is calculated to be $5{\cdot}9 \times 10^{-13}$. The observations of Trey, that the conductivity of an aqueous solution of caustic soda is decreased and that of dilute ammonia is increased by the addition of glucose, can also be explained by assuming that glucose is an acid of the strength described above, and that the salts have a conductivity similar to that of the caproates.

The enormous influence of bases in accelerating the changes of rotatory power is well known, and experiments are described which show that this effect is proportional to the concentration of the hydroxyl-ions. Ammonia alone is too strong a base for experimental purposes, but by mixing it with a known excess of ammonium chloride (which does not directly influence the change) its basic character can be diminished to any desired extent, and the influence of such mixtures on the velocity-constant is proportional to the calculated concentrations of the —OH ions within the limits of experimental error. Experiments are also described in which the following weak bases were used: pyridine, aniline, *α*-picoline, ethylenediamine, and tri-, tetra- and penta-methylenediamine.

Acids have a much smaller catalytic effect than bases, and here the influence on the velocity constant is proportional to the *square root* of the concentration of the hydrogen ions, as is shown in a very satisfactory way by experiments with HCl and HBr. Neutral salts which accelerate the change in basic solutions do not produce any marked effect in acid solutions, and a mixture of HCl and KCl in molecular proportions gave a constant (0·0184) agreeing closely with the value obtained (0·0186) when only the HCl was present. T. M. L.

677. *Electrostriction of Ions in Organic Solvents.* **G. Carrara** and **M. G. Levi.** (N. Cimento, 12. pp. 284–288, Nov.–Dec., 1900. From the Gazz. Chim. Ital. t. 30. II., 1900.)—An inquiry into the relations between the variations in the molecular volume of a substance in various solvents at various dilutions, and the electrolytic dissociations of the same substance. The question is, in other

words, whether these variations depend (Drude and Nernst, Zeit. für Phys. Chem. 15. 79, 1894) on the electrostriction of the solvent by the electrostatic charge of the ions. The molecular volume ϕ (or "equivalent" volume in the case of salts of polyvalent metals) is $A/Q - 1000(s/Q - 1)/m$, where A is the molecular (or equivalent) weight, Q is the corrected density of the solvent at 25°, s is the corrected density of the solution at 25°, and m is the number of molecules (or equivalents) per litre of the solution. The results of a large series of determinations are in accord with the Drude and Nernst theory. The greatest variations in the molecular volumes take place in those electrolytes in which the dissociation, though not great in not very dilute solutions, progresses regularly with the dilution. The investigations are to be continued. A. D.

678. *Electrodeposition of Metallic Lead, and the Formation of Lead Sponge.* **L. Glaser.** (Zeitschr. Elektrochem. 7. pp. 365–369, Dec. 13, and 381–386. Dec. 27, 1900.)—The researches of Foerster and Günther on the electrolysis of zinc chloride solutions [Abstract No. 151 (1899)] have induced the author to make a somewhat similar series of experiments in the case of lead salts. Neutral, acid, and alkaline solutions were examined, and the following conclusions arrived at. Brilliant, coherent deposits of metallic lead may be obtained by the electrolysis of *acid* solutions of lead nitrate or acetate. The formation of spongy lead takes place in feebly acid or neutral solutions, as in the case of zinc, and is to be attributed to the separation of basic salts which are soluble with difficulty and which impede the uniform crystallisation of the metal at the kathode. The formation of lead sponge is prevented by the addition of ammonium persulphate, chlorine, pyrogallol, hydroquinone, &c., *i.e.*, by substances tending to dissolve the basic salts referred to, or to reduce the lead hydroxide. In the case of alkaline solutions good metallic deposits are obtained by the use of a low e.m.f. and vigorous agitation of the electrolyte; otherwise hydrogen is evolved and spongy lead is formed. N. L.

679. *Electrolysis of Fused Salts.* **F. M. Lyte.** (Chem. News, 82. pp. 271–272, Dec. 7, 1900.)—In connection with a recent paper by A. Helfenstein [see Abstract No. 1713 (1900)] on the application of Faraday's law to the electrolysis of some fused metallic salts, the author describes some results obtained several years ago, but hitherto unpublished, in the electrolysis of fused lead chloride. In the experiments referred to, little or no chlorine was evolved, but a small quantity of oxygen was produced, and a cloud of metallic lead appeared to emanate from the kathode and disappear in the neighbourhood of the anode. The phenomenon is considered to be due to the decomposition of lead oxychloride, formed by the action of atmospheric oxygen on the lead chloride, and not to the solution of metallic lead in the lead chloride, as suggested by Helfenstein. N. L.

680. *Efficiency in Manufacture of Calcium Carbide.* **J. B. C. Kershaw.** (Electrician, 46. pp. 164–165, Nov. 23; 245–246, Dec. 7; and 267–268, Dec. 14, 1900.)—The theoretical yields of carbide furnaces calculated by nine authorities are quoted, and it is shown that the great discrepancies are due to the figures being in some cases based upon incorrect data. They range from 1,523 to 3,293 kw. hours per ton of an 80 per cent. carbide, but in the calculation giving the lowest number, no regard was paid to the heat necessary to raise the materials to the reaction-temperature, from 30 to 50 per cent. of the heat-energy required being thus neglected. It is pointed out that the

data for these calculations are not known with sufficient certainty to warrant the acceptance of any one figure, but Gin's calculation in *L'Éclair. Élect.* (May 6, 1899) is considered by the author to be the most reliable. Taking the temperature of reaction as 3,300° C., he finds that 212,000 calories are required per gramme molecule of calcium carbide, which is equivalent to an expenditure of 3,837 kw. hours per ton of pure carbide, or of 3,069 kw. hours per ton of the 80 per cent. material.

Seven published statements as to the experimental and estimated number of kw. hours necessary to produce one metric ton (2,204 lbs.) of an 80 per cent. carbide are quoted, and these range from 4,105 to 6,514 (averaging about 4,800). Thirteen similar statements of actual results show a range from 3,576 to 5,960 (averaging nearly 4,500) kw. hours. But of these the following three are regarded as the most reliable and striking: Keller's statement at the Paris Congress (1900) that the latest form of the Gin and Leleux furnace yielded 6·2 kg. of carbide per kw. day (= 3,871 kw. hours per ton of 80 per cent. carbide); Carlson's statement in the *Zeits. f. Elektrochemie* (1900) that the continuous furnace yielded 4·5 kg., and the intermittent furnace 5·8 to 6·5 (mean = 6·15) kg. of 76 per cent. carbide per kw. day (= 5,616 and 4,104 kw. hours per ton of 80 per cent. carbide); and Lewes' statement in *Acetylene* (1900) that, at Foyers, the best results have been 3·78 kg. pure carbide per e.h.p. day (= 3,788 kw. hours per ton of 80 per cent. carbide). The three types of furnace used to produce the last-named results are then described, the German type with an illustrative wood-cut. These are: the furnace of the *Deutsche Gold und Silber Scheide Anstalt* (an intermittent type of furnace, with a system of renewing the charge so rapidly that the utilisation of electrical energy is practically continuous, the current values being 2,000–3,000 amperes at 60–65 volts); the Willson Furnace; and the Gin and Leleux furnace. The highest yields yet known have been from intermittent furnaces, and the continuous type is being used chiefly where power is cheap and labour dear. Economy is chiefly to be sought in the utilisation of the waste gases, and in the preparation of the charge, the use of coarser fragments being, probably, of advantage. W. G. M.

681. *Calcium Carbide Plant at Milan.* **V. Lucchini.** (Elettricita, Milan, 19. pp. 758–763, Dec. 1, 1900.)—Power is taken from the Paderno three-phase substation at 3,600 volts, and is transformed to a potential of 34 volts between each phase and the centre by transformers of the capacity of 1,000 kw. A 30-h.p. three-phase motor drives the grinding machines. Calcium carbonate, from Rezzato in Brescia, is burnt in a Hoffmann furnace of a capacity of 4 tons per day; the resulting product contains from 85 to 94 per cent. pure lime. The coke used contains 85 per cent. of carbon. Two grinding machines, with automatic feed, deliver 1,500 kilos of lime and 1,300 kilos of coke per hour. The mixture, in the proportion of 64 to 68 parts of coke to 100 of lime, is taken to a bunker above the furnaces. Four furnaces, by the Compagnie Electro-Métallurgique des Procédés Gin et Leleux, take each 225 kw. at 28 to 33 volts. The bottom of the furnace constitutes one electrode, and consists of two layers, one of low and the other of high resistance; the latter, being heated by the passage of the current, maintains the carbide liquid. The other electrode descends vertically into the centre of the furnace, and is capable of a vertical motion. Three furnaces are worked together, one in each phase of the three-phase supply. Carbide is run out every two hours, when from 115 to 175 kilos are obtained from each furnace; the furnaces are run for 80 hours, each yielding a block of carbide weighing

from 1,100 to 1,350 kilos. Their production is 5·6 kilos per kw. day. The electrodes last about 150 hours ; they are of graphite, or a mixture of graphite and anthracite, and are heated for ten hours at 1,200° C. before use. The furnace gases are drawn off by a ventilator. The carbide blocks are broken up into pieces of about two cubic decimetres, which are then treated by a crusher ; a sorter then separates the crushed ore into five different sizes, for packing in tins holding from 2 to 25 kilos. The carbide yields from 300 to 312 litres of acetylene per kilo. G. H. B.

682. *Manufacture of Ferro-Titanium at Niagara.* **O. E. Dunlap.** (Elect. Rev. 48. pp. 99–100, Jan. 18, 1901.)—The author states that of the iron ore available in the United States at least 30 per cent. is unfitted for use, owing to its percentage of titanium. A process has been investigated for successfully treating this titaniferous iron ; and it is therefore apparent that if this ore can be easily smelted, the country's wealth will make material advancement. At the present time about 500 lbs. of the new alloy, ferro-titanium, are turned out every twenty-four hours at Niagara. Through large furnaces containing scrap-iron, titaniferous ore, and small blocks of aluminium, a powerful current is sent. The result of the reduction is pure oxide of aluminium, ferro-titanium (which is formed into cakes), and a slag that is valuable. O. J. S.

683. *Anodes for Electrolytic Alkali Cells.* **A. T. Weightman.** (Ind. Électrochim. 4. pp. 94–96, Oct., 1900. From the Engineering and Mining Journal, Aug. 4, 1900.)—The essential characteristics of good anodes are high conductivity and durability. Only a few substances possess these in the required degree. Lithanode (peroxide of lead), patented by Fitzgerald in 1890, failed because it was attacked by hydrochloric acid. Hoepfner, Liveing, and Parker & Robinson have patented the use of other compounds for anodes, but none of these have been very successful.

Carbon, when used as an anode in the cell, is not attacked by the chlorine, but by the oxygen and oxy-chlorine compounds which in most cases accompany it. This disadvantage is met by Richardson and Holland, and by Connor, by reducing the first cost of fresh carbon anodes. These inventors use rough blocks of gas-carbon and build up anodes of any size and form by the use of lead and cement. Other inventors have sought to minimise the liberation of oxygen and its compounds in the anode chamber of the cell by improved construction.

The influence of current density and of temperature upon the life of the carbon anodes is not sufficiently recognised. The disintegration is more rapid the higher these are maintained. Graphitized carbon is less attacked than ordinary carbon, and at Widnes and Niagara the Castner cell was originally worked with anodes made by Castner's own process. This consisted in heating ordinary carbons in an electric furnace to a white heat, the carbons being embedded in carbon dust during the heating and until cold. Most of the electrolytic alkali works now use graphitized carbons manufactured under Acheson's patents at Niagara. This process depends upon the decomposition of metallic carbides at the temperature of the electric furnace. In order to test the durability of samples of various carbons, it is best to submit them to a ten hours' laboratory trial in a 10 per cent. solution of sulphuric acid, and to determine their loss in weight.

The article closes with a reference to the use of platinum and its alloys, and to the various patented devices for securing large surface area of this

metal at a low cost. One of the best of these is that devised by Le Sueur and in use at Rumford Falls. Short lengths of platinum wire are bunched together in glass tubes, and electrical connection is obtained by pouring in a small quantity of mercury. Such anodes cost only about 75 cents each and are highly efficient. J. B. C. K.

684. *Carbon Electrodes.* **F. Winteler.** (Zeitschr. Elektrochem. 7. pp. 356–359, Dec. 6, 1900.)—For use in the electrolysis of chloride solutions carbon anodes should satisfy three conditions: (1) The proportion of hydrocarbon should be small—a result which can only be secured by prolonged burning of moulded rods of gas-carbon mixed with tar or pitch; (2) the gas must be liberated as much as possible at the surface of the electrode, and the current density should therefore not exceed 2 amperes per sq. dcm.; (3) the carbon must not contain soluble impurities, and the fact that gas-carbon contains little but insoluble silicates of aluminium and iron renders it specially good in this respect. Carbon electrodes, however, very soon perish if oxygen is liberated at the anodes, and the presence of, for example, sodium sulphate as an impurity in the electrolysis of salt solutions greatly shortens the life of the carbons.

In the manufacture of aluminium the presence of hydrocarbons in the carbon of the electrode is of no importance; the chief essential is that the electrodes should be free from silica and silicates, since otherwise silicon fluoride is formed by the action of the fluorine, causing a loss of fluorine from the bath; another danger is the reduction of the silica to silicon by the aluminium at the bottom of the bath, which would cause a waste of aluminium and render the metal impure. The best carbon for this purpose is an ash-free carbon such as is formed in making oil-gas by "cracking" petroleum oils.

For carbide manufacture the presence of hydrocarbons and of silica is of no importance, and the chief essential is that phosphates should be absent, as otherwise calcium phosphide is produced, and the acetylene is contaminated with phosphoretted hydrogen. T. M. L.

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685. *Chemical Activity of the Silent Discharge.* **Berthelot.** (Comptes Rendus, 131. pp. 772–781, Nov. 12, 1900.)—This paper treats of the chemical reactions produced in gases by the various forms of silent electric discharge [see further Abstract No. 533 (1898)]. T. H. P.

686. *Solubility of Alkali Chlorides in Caustic Alkalis.* **F. Winteler.** (Zeitschr. Elektrochem. 7. pp. 360–362, Dec. 6, 1900.)—A knowledge of the solubilities of the chlorides and chlorates of the alkali metals in solutions of the hydroxides of the latter is of importance in connection with the treatment of the liquids obtained in the electrolytic preparation of caustic alkalis, &c. The author has therefore determined, and recorded in tabular form, the solubilities at 20° C. of potassium chloride in solutions of caustic potash of various strengths, of potassium chlorate in potassium chloride solutions, of sodium chloride in caustic soda, and of sodium chlorate in sodium chloride. The specific gravities of the solutions are also given. N. L.

687. *Electric Furnaces.* **Keller.** (Écl. Électr. 24. pp. 312–320, Aug. 25, 1900. Paper read before the International Electric Congress at Paris. Abstract in the 'Electrician, Sept. 28, 1900.)—A classification of the various types of furnace, and a summarised account of the more important of them, with a note as to electrodes, current conditions, and a brief sketch of the development of the industries employing the electric furnace. W. G. M.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

688. *Delaunay-Belleville's High-speed Engine.* **M. Aliamet.** (Électricien, 20. pp. 51–56, July 28; 121–125, Aug. 25, 1900.)—High-speed engines have been very largely developed of late years for the purpose of driving dynamos, and though from a theoretical point of view high speeds are advantageous, from a practical point of view they introduce several difficulties. The lubrication is no longer a simple matter. Rubbing surfaces wear more quickly, and, if they are not carefully watched, knocking is the inevitable result. This has led to the use of high-speed single-acting engines. High-speed engines consume more steam than slower-running engines of the same power. The principal reasons for this increased steam consumption are as follows: increased clearances which have to be filled at each stroke, and the impossibility of using valves permitting of a high ratio of expansion in the cylinders. The cylinders of the Delaunay-Belleville engine are placed in tandem. The valves are piston valves and driven off one eccentric.

The 75-h.p. engine has the following dimensions:—

H.P. cylinders	7·48 inches diam.
L.P. ,,	11·81 ,, ,,
Stroke	9·84 ,,
Cylinder ratio	2·55
Revolutions per minute	360
Initial pressure	120 lbs. per square inch.

The oil pump of this engine is valveless and is worked on the "oscillating-cylinder principle" off the end of the crank-shaft by a small crank. The oscillations of the pump are made to open and close the ports. The pump forces the oil into a reservoir under pressure. This is fitted with a safety valve to keep the pressure from rising too high, and a steam coil runs through it to keep the oil thoroughly fluid.

Careful provision is made for cleaning out the various oil passages, should any of them become blocked. The pistons and valves are greased by the use of "Valvoline" in the steam in the usual way. The governor is of the ordinary ball type, working a butterfly or a double-beat valve.

A series of trials was carried out under the supervision of Compère, chief engineer to the Paris Steam Users Association. The engines exhausted into a separate condenser from which the water was carefully measured, and each engine was tested, both condensing and non-condensing. Cards were taken every quarter of an hour. When working with a vacuum the initial pressure was 114 lbs. per square inch, and with no vacuum it was raised to 143 lbs. per square inch, to keep the h.p. the same. Cut-off was at about 50 per cent. The results of the trial show a good steam consumption and a high mechanical efficiency, due, no doubt, to the excellent oiling arrangements. The results of the tests go to show that as the number of cylinders increases, the mechanical efficiency decreases, and that it is useless to increase the number of expansions without also increasing the initial pressure.

The following table gives the principal results obtained by Compère;

but it should be noted that in two instances the imperfect working of the indicators has given too high readings of the power.

	Compound Engine.		Triple Expansion.		Quadruple Expansion.	
	Condensing.	Non-condensing.	Condensing.	Non-condensing.	Condensing.	Non-condensing.
Duration of trial ...	2 hrs.	2 hrs.	1 hr. 30 mins.	1 hr.	2 hrs.	2 hrs.
Initial pressure lbs.	114	143	194	194	232	232
Revs. per min.	366	363	360	360	360	360
Horse-power	h.p. 39·38	h.p. 41·56	h.p. 99·16	h.p. 99·03	h.p. No. 1 26·55	h.p. No. 1 25·7
			m.p. 96·25	m.p. 92·73	m.p. { No. 2 29·84 / No. 3 28·45	m.p. { No. 2 28·1 / No. 3 26·8
	l.p. 43·69	l.p. 42·83	l.p. 95·85	l.p. 59·37	l.p. No. 4 30·76	l.p. No. 4 13·0
Total h.p.	83·07	84·39	291·26 [1]	247·13	115·60	93·5
Brake h.p.	79·16	78·50	295·6	225·4	112·29	83·04
Steam per i.h.p. in lbs.	19·33	22·38	—	18·06	15·24 ?	19·22
,, ,, b.h.p. ,,	20·30	24·06	15·98	19·80	15·69 ?	21·90
Mech. efficiency ...	95 per cent.	93 per cent.	—	91 per cent.	97 per cent. ?	89 per cent.

[1] This figure is incorrect.

L. S. R.

689. *Steam Turbines.* (Railroad Gazette, 32. pp. 857–860, Dec. 28, 1900. Extracts from a paper by **F. Hodgkinson** read before the Engineers' Society of Western Pennsylvania, Nov. 20, 1900. Also Elect. Rev. N.Y., Dec. 26, 1900, and Jan. 5, 1901.)—Descriptions of the Laval and Parsons turbines are given with very clear diagrams and illustrations; also a method of measuring the pressure at any point in a Laval steam nozzle by means of a small exploring tube attached to a pressure gauge. A test of a Laval turbine working at 307·8 h.p. gave 13·92 lbs. of steam per h.p. hour, steam being at 192 lbs. and superheated 69° F. A Parsons turbine working at 1,200 kw. has run for 14·03 lbs. per e.h.p. hour = 11·9 lbs. per i.h.p. hour [see Abstract No. 1135 (1900)]. As an example of the actual force on the blades, it is stated that in a 300-kw. Parsons turbine in which there were 16,095 moving blades, the forces exerted varied from 0·89 to 1·04 ounces per blade.

H. R. C.

690. *Ellis and Eaves' Induced Draught.* (Mech. Eng. 6. pp. 847–849, Dec. 15, 1900.)—The various systems of mechanical draught are well known. In this paper attention is redirected to the advantages of the "induced" draught system as worked out by Ellis and Eaves, and applied to marine and land installations—those specially quoted being that of the ss. *Inchkeith* and the marine-type boilers at the Sheffield Electric Light and Traction Stations.

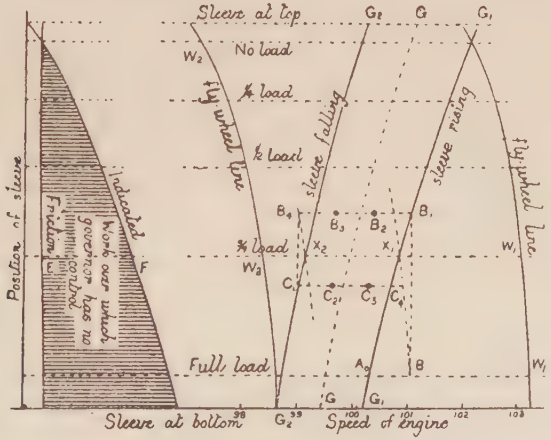
The air superheater, now fitted in conjunction with Ellis and Eaves' apparatus, is an efficient one, as it is possible to heat the air to over 300° F. by its means. Valves or dampers are provided to switch off any furnace from the fan suction and thus prevent the inrush of cold air from the stoke-hold when the fire-doors are opened.

F. J. R.

691. *Tests of Speed Variation by Tuning-Forks.* **F. Göpel.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1359–1363, Oct. 6, and 1431–1435, Oct. 20, 1900. Communicated by the Physikalisch-Technische Reichsanstalt.)—A brass disc is placed on the end of the rotating shaft, and a vibrating

tuning-fork is made to trace a sinuous spiral curve on its smoked surface. From this curve can be found the degree of uniformity of speed through one or more revolutions. Electromagnetic tuning-forks were not used on account of the inconstancy of their frequency. For speeds between 70 and 300 r.p.m. a fork with a periodicity of 435 per second was found to be suitable in every respect. A full exposition is given of the method used in analysing the results. In the case of a 30-h.p. gas dynamo with a load of 7·2 h.p., the speed variation in the cycle of two revolutions was 0·86 per cent. [No particulars are given of the flywheel.] With a load of 4 h.p. the variation was 0·56 per cent. A steam dynamo of 35 h.p., with a load of 23 h.p., gave variations of 3·5 per cent. and 1·2 per cent. respectively at different times. A few other results are quoted, and some curves are given showing the angular speed for various positions of the crank through one or more strokes. W. H. E.

692. *Flywheels.* **A. Sharp.** (Mech. Eng. 6. pp. 628–631, Nov. 3, 1900, and 660–663, Nov. 10, 1900. Paper read before the Manchester Association of Engineers, Oct. 27, 1900.)—After an investigation of the variation of crank effort and illustrations of the coefficients of fluctuation of energy for various types of engine with calculation of the flywheel energy required, the author illustrates on a single diagram the combined effects of flywheel and governor.



The co-ordinates are speed of engine and position of governor sleeve. The subsidiary diagram on the left gives as abscissæ the work capable of being done by steam which has already been admitted to the engine, this being, of course, greatest when the governor is down and full steam admitted. The line G G is the characteristic of the governor, and, allowing for friction, $G_1 G_1$ gives the relation between speed and position when rising, $G_2 G_2$ when falling. If the conditions are as represented at X_1 and the whole load is thrown off the engine, then the amount of work E F may be expended in increasing the speed to W_1; $X_1 W_1$ being inversely proportional to the mean energy of the flywheel. In this way, from the data of the engine, the flywheel lines $W_1 W_1$ and $W_2 W_2$ are plotted. To examine the combined effect of governor and flywheel, suppose, for instance, that the engine had been running at full load, one-quarter of which is suddenly removed; the increase of speed may be the difference between $A_0 W_1$ and $X_1 W_1$; this is set off as A B and B B_1 drawn

vertically; the governor would rise to B_1. This corresponds to a smaller load than that on the engine, and the speed falls, being represented at the end of successive strokes by $B_2 B_3$, &c. When the speed falls outside $G_2 G_3$, as at B_4, the governor would fall to C_1 and the speed gradually rise through $C_2 C_3$; the cycle being repeated on a smaller scale, *i.e.*, starting now from C_4 instead of B. If the flywheel is not sufficiently powerful, so that the flywheel line is less steep than the governor line, the governor will hunt persistently. If the flywheel line is vertical the engine will most quickly settle down to its new speed after a change of load; while if the flywheel is still more powerful, so that the line slopes in the same direction as the governor lines, the engine will quickly approach its new speed and not overshoot it.

An examination of the stresses set up in the rim and arms of a rotating flywheel follows, and is accompanied by illustrations of various types of design, including one by the author, in which the cast-iron rim is connected to the boss by numerous tangent spokes. H. R. C.

GAS AND OIL ENGINES.

693. *Heat Efficiency of a Gas Engine as Modified by Time of Ignition.* **C. V. Kerr.** (Horseless Age, 7. pp. 29–31, Dec. 12, 1900. Abstract of a paper read before the American Society of Mechanical Engineers, N.Y., Dec., 1900.)—A record of an interesting series of tests made upon a single-cylinder gas engine, having a cylinder 6¾ in. diameter and a stroke of 12 in.; the combustion chamber clearance was about 35 per cent., and the normal speed 240 r.p.m. All provisions were available for accurately recording the b.h.p., the engine speed, the fuel and air consumption, the heating value of the gas, the number of gas admissions, and the power developed in the cylinder. A reliable electric-ignition device, by means of which the precise moment of ignition could be varied at will over a large range (4½ inches before to 4½ inches after) about the dead centre, was employed. Previous tests had been made with this engine, and its general characteristics were well known; from these it was seen that, with 6·6 cubic feet of air and 1 cubic foot of gas as the working mixture, with the heat value of the gas at from 811 to 867 B.Th.U., and with the cooling-water kept at 160° F., the compression pressure was about 60 lbs. per square inch, the explosion pressure was about 240 lbs. per square inch, the indicated h.p. varied from 3·8 to 11, and the heat efficiency remained nearly constant over this range of load at 22 per cent. In the recent tests runs of one hour each were made with the igniter set to various positions, and three different loads were experimented with—no-load, 2·5 b.h.p., and 5 b.h.p. For each load the point of ignition was made as early and as late as would enable the engine to continue running at normal speed. A hit-and-miss governor was used. Indicator cards were taken at frequent intervals, and the general results obtained showed the following further characteristic features of this particular engine under the special conditions imposed: On no-load, ignition was varied from $+ 4\frac{1}{32}$ inches (before the end of the compression stroke) to -2 inches (after the dead centre); the highest heat efficiency was at $+ \frac{1}{2}$ inch, the highest explosion pressure was at an earlier ignition-point, the terminal compression varied from 55 to 65 lbs. per square inch, and the pressure released varied between 29 and 54 lbs. per square inch. With a load of 2·5 b.h.p. the highest efficiency was obtained at $+ \frac{1}{2}$ inch and the maximum explosion pressure at $+ 2\frac{1}{2}$ inches. With the 5-b.h.p. load the maximum efficiency was at dead-centre ignition

and the highest explosion pressure at $+2\frac{1}{2}$ inches, but so wide a range of ignition could not be secured at this load, and no runs with any greater load were therefore attempted. Mechanical efficiency was found to increase slightly with later ignition. It was shown that ignition should never occur later than the dead centre so far as heat efficiency is concerned. The interval between ignition and maximum pressure was almost constant (0·03 sec.), for ignition before dead centre, but this interval increased decidedly with later firing-points. A summary of these tests is given in the following table :—

Point of Ignition. Inches.	Length of Run. Minutes.	Cubic Feet Gas per Hour.	Explosions per Minute.	Engine Speed r.p.m.	Horse-Power.		Average Friction h.p.	B.Th.U. in Gas.	Heat Efficiency.	
					Indicated.	Brake.			In Cylinder.	At Brake.
$+4\frac{1}{2}$	60	65·72	44·3	238	2·63	0		893	0·114	0
$+2\frac{1}{2}$	30	54·24	34·6	,,	2·82	0		,,	0·148	0
$+1\frac{1}{2}$	60	43·52	27·3	,,	2·63	0		,,	0·172	0
$+\frac{1}{2}$	60	40 08	25·0	,,	2·63	0		,,	0·187	0
± 0	60	40·47	25·0	,,	2·31	0	2·56	,,	0·163	0
$-\frac{1}{2}$	60	65·83	41·1	,,	2·83	0		,,	0·123	0
-1	60	74·45	50·3	,,	2·54	0		,,	0·097	0
$-1\frac{1}{2}$	40	85·02	54·4	,,	2·41	0		,,	0·081	0
-2	60	115·26	83·7	,,	2·21	0		,,	0·055	0
$+4\frac{1}{2}$	60	106·82	79·2	,,	5·08	2·5		938·5	0·128	0·063
$+2\frac{1}{2}$	60	83·23	56·7	,,	4·73	,,		899·2	0·160	0·085
$+1\frac{1}{2}$	60	71·95	50·1	,,	4·67	,,		938·5	0·176	0·095
$+\frac{1}{2}$	60	71·50	47·3	,,	4·73	,,	2·08	899·5	0·186	0·098
± 0	60	66·75	45·0	,,	4·44	,,		938·5	0·181	0·102
$-\frac{1}{2}$	60	97·18	68·6	,,	4·35	,,		977·0	0·116	0·067
-1	60	118·42	86·7	,,	4·14	,,		955·0	0·093	0·056
$-1\frac{1}{2}$	60	147·6	109·3	,,	4·47	,,		955·0	0·081	0 045
$+2\frac{1}{2}$	60	131·78	96·7	,,	7.96	5·0		899	0·171	0·108
$+1\frac{1}{2}$	60	120·44	88·8	,,	7.46	,,		,,	0·175	0·118
$+\frac{1}{2}$	60	108·21	75·6	,,	7.24	,,	2·31	,,	0·189	0·130
± 0	60	105·25	82·0	,,	7.33	,,		,,	0·197	0·134
$-\frac{1}{4}$	60	159·73	108·6	,,	6.56	,,		,,	0·107	0·082

A. G. N.

694. *Tests of Benzine Motors.* **H. Güldner.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1320–1324, Sept. 29 ; and 1728–1732, Dec. 15, 1900.)—This paper describes tests made by the author on two car-motors by Henile and Wegelin and one by the Aachen Stahlwaren-Fabrik. The means employed to measure the b.h.p. and the i.h.p. are fully described, and numerous indicator diagrams are reproduced. The following are the results obtained :—

Henile and Wegelin motor : Single cylinder ; radiation-cooling ; electric ignition ; speed, 650 r.p.m. ; two-speed ratios, 1 : 2·4 and 1 : 5·0. B.h.p. at 712 r.p.m., 2·71. B.h.p. at 650 r.p.m., 2·47. Benzine consumption per b.h.p. hour at full-load, 0·721 kg. Mechanical efficiency at low-speed ratio, 0·774 ; at high-speed ratio, 0·709.

Aachen Stahlwaren-Fabrik motor : Single-cylinder ; water-cooling ; electric

ignition; spray carburettor; speed, 1,400–1,500 r.p.m.; two-speed ratios, 1 : 6 and 1 : 14. B.h.p. at 1,485 r.p.m. 2·87. Benzine consumption per b.h.p. hour, 0·807 kg. Mechanical efficiency at low-speed ratio, 0·80. G. H. B.

695. *Compound Explosion Engines.* **C. P. Malcolm.** (Horseless Age, 7. pp. 14–15, Dec. 5, 1900.)—After giving the following advantages which would be gained by a compound construction for automobile oil motors—silence of exhaust, increase of power, and greater uniformity of turning moment—the author proceeds to describe a simple form of arrangement in which a low-pressure cylinder is placed between two alternately acting cylinders of the usual "Otto" cycle type. In this engine the explosion cylinders work upon cranks which are set opposite to, and on the same crank-shaft as, a central crank; the low-pressure cylinder is connected to this central crank. All three pistons have the same length of stroke, but the area of the low-pressure cylinder is three times that of each of the other cylinders. Each explosion cylinder exhausts direct into the central cylinder through a valve, and the expanded gases pass from this latter cylinder to the atmosphere, during each inward stroke of its piston, through another valve. A pair of inwardly opening suction valves are also fitted in the head of the low-pressure cylinder in order to allow air to enter, in the event of either explosion cylinder missing fire. The writer assumes that the pressure of the exhaust gases acting upon the low-pressure piston is about 45 lbs. per square inch, and that they expand during the working stroke of this cylinder to atmospheric pressure. It is pointed out that this system is by no means new—in the seventies or early eighties such a motor was patented—but that valve construction and mechanical details have been too faulty to ensure success hitherto. The author incidentally, but strongly, condemns the use of poppet valves for all gasoline motors, and advocates the employment of water-jacketed and balanced piston valves. A. G. N.

AUTOMOBILISM.[1]

696. *Brolliet Motor.* **J. M. Hertrich.** (Locomotion Automobile, 7. pp. 804–805, Dec. 13, 1900.)—A description with a diagrammatic drawing of a motor in which two parallel cylinders are fitted with double pistons. Four combustion chambers are formed by the closed ends of the two cylinders. A rocking arm is connected to both pistons, and it passes through slots in the cylinder walls. Tubes pass through the centre of the pistons and the cylinders from end to end, and water is circulated through these instead of being led into outside jackets. A. G. N.

697. *The Legrand Car.* (Locomotion Automobile, 7. pp. 802–804, Dec. 13, 1900.)—This vehicle, which weighs about 14 cwt., and is fitted with springs between the underframe and the axles, has several interesting features. The body is mounted upon a separate set of springs, between it and the underframe. The steering pillar and wheel are fixed to the body, and they actuate the front wheels through a flexible connecting system. Two entirely distinct 3-h.p. De Dion motors are fitted, one on each side of the underframe; they are placed low down and at about the centre of the car longitudinally. Each motor is provided with a wood pulley upon its crank-shaft, and the power is transmitted from them both to the two extremities of a toothed-wheel change-speed-gear shaft by means of leather belts. Loose pulleys are mounted upon

[1] Electric Automobiles are described in the section dealing with Electric Traction.

independent idle shafts in such a way that they face the fixed pulleys on the gear shaft. A common striking gear enables the driver to throw the two belts from the loose to the fixed pulleys. It has been found that whatever the relative positions of the two pistons may be when starting the motors, they always fall into synchronism after starting, and it is said that the vibration caused by either motor separately is largely cancelled by the operation of the other. A single chain transmits the power from the gearing to a differential gear upon the rear axle. Water cooling is used for the cylinders, and this is circulated through a radiator by a pump in the usual manner. Each motor has its own carburettor and electric ignition device, but the timing regulator with which the driver controls the latter is common to both motors. The illustrations accompanying the description show the general form and arrangement of the chief parts. A. G. N.

698. *Vinet Motor Car.* **P. Sarrey.** (Locomotion Automobile, 7. pp. 818–820, Dec. 20, 1900.)—The author describes a light petrol car, of neat design and appearance, for seating two persons. It is propelled by a de Dion and Bouton engine of 3½ h.p. or of 5 h.p. mounted at the front of a tubular underframe, and covered by a bonnet, the front of which is cut away to fit the coils of the radiator for cooling the jacket-water of the engine. The underframe is sprung from the front axle by the usual plate springs, and is bent down to the level of the live rear axle, the enclosing tube of which forms the back member of the frame. The carriage body is independently sprung from the tubular frame by scroll plate springs at the back, and is pivoted upon it in front. The power is transmitted from the engine first by a spur gear to a short shaft carrying a belt pulley, and thence by an equal belt drive to a counter-shaft at the back of, and level with, the driving axle. Three spur pinions are mounted on this shaft, and these may be brought into engagement, by side contact, with corresponding spur wheels mounted on the exterior of the differential gear on the driving axle, and forward speeds of 5, 15, and 26 miles per hour obtained. By means of an intermediate pinion introduced between one pair of the forward driving pinions and the wheels when these are out of engagement, a reverse motion may be imparted to the car. The belt drive is controlled by a jockey pulley operated by a pedal, so that the power may be applied to or cut off from the driving gear as desired. The controlling levers for the engine and carburettor are mounted upon the steering pillar, and those for the change-speed gear, reverse, and brakes are at the driver's left hand, his right hand being, contrary to the usual practice, always upon the steering wheel, and his seat at the left-hand side facing the forward direction. The article is illustrated by two photographs and plan and elevation drawings. C. R. D'E.

REFERENCE.

699. *Brakes for Automobiles.* **M. L. Bochet.** (Horseless Age, 7. pp. 23–25, Nov. 21, 1900. Report presented to the International Automobile Congress.)—The author considers the employment of the motor itself for retarding or reducing the speed of automobiles, and he deals separately with cars propelled by each of the three well-known systems—steam, oil, and electricity. He states that this method of braking is to be preferred, and he then proceeds to consider the various types of mechanical brakes now in use : shoe brakes and band brakes. After mentioning the different devices which are generally fitted by builders of these vehicles, and after referring to the French regulations concerning this subject, he concludes with a consideration of the various means employed for preventing automobiles from running backwards down hills. A. G. N.

GENERAL ELECTRICAL ENGINEERING.

700. *Phénix Accumulator.* **J. Reyval.** (Écl. Électr. 25. pp. 454–456, Dec. 22, 1900.)—This article only deals with the construction of the electrodes used in the latest type of cell. Each consists of a positive and negative made up together by packing lead peroxide round a central lead rod within a porous-ware tube, and surrounding it externally with a layer of spongy lead in which is embedded a lead wire wrapped spirally about the tube. An outer casing of thin sheet lead perforated with a large number of small holes is provided. The complete composite electrode weighs about 650 gms., and is 230 mm. high by 35 mm. in diameter. E. J. W.

701. *Lee-Coll Accumulator.* (Automotor Journal, 5. pp. 112–114, Dec., 1900.)—The positives of this cell consist of a number of porous-ware tubes containing lead peroxide packed round a central conducting core of lead. The negatives are sheets of fine copper gauze bent and shaped so as to encircle each positive. The electrolyte contains sulphates of zinc and cadmium, from which these metals are deposited at the negatives on charging. Some curves are given to illustrate certain peculiarities in the discharge of the cells. E. J. W.

702. *Estimation of the Size of Accumulator Batteries.* **E. Suchy.** (Zeitschr. Elektrotechn., Wien, 18. pp. 609–610, Dec. 16, 1900.)—A method of calculation is given for the necessary size of a battery to provide for a demand which follows a certain load curve. It is assumed that within practical limits the increase of capacity with the time of discharge follows the linear law $C_n = a(1 + bT_n)$, in which C_n is the capacity for a discharge lasting T_n hours, and a and b are constants. The value of b for batteries of usual construction is 0·06. The formula,

$$a = \frac{t\Sigma i}{1 + ntb}$$

is then simply deduced, t being the length of a time interval into which the whole period may be divided, and Σi the sum of the currents throughout these intervals. The method is illustrated by the following simple example. A battery has to provide 50 amperes for two hours, then 100 amperes for one hour, and finally 30 amperes for 5 hours. Here—

$$a = \frac{1 \times (50 + 50 + 100 + 30 + 30 + 30 + 30 + 30)}{1 + (8 \times 1 \times 0{\cdot}06)} = 237$$

Hence for a three-hour discharge battery, the necessary capacity is given by

$$C_n = 237(1 + 0{\cdot}06 \times 3) = 280 \text{ ampere-hours,}$$

and for a five-hour,

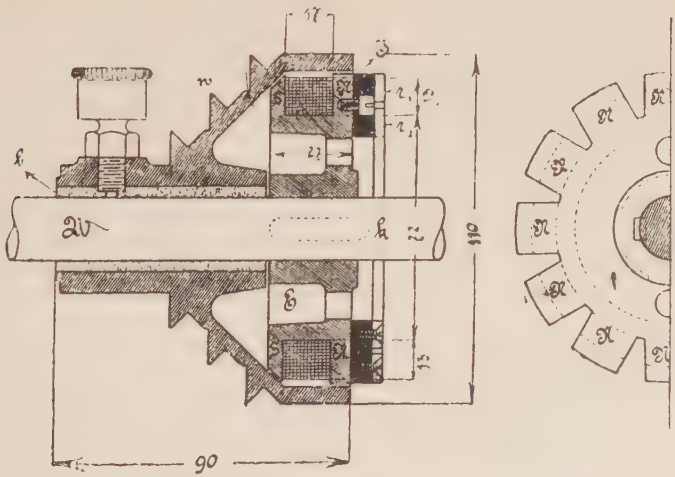
$$C_n = 237(1 + 0{\cdot}06 \times 5) = 308 \text{ ampere-hours.}$$

W. W. H. G.

703. *Wüste and Rupprecht's Accumulator Switch.* **E. Dick.** (Zeitschr. Elektrotechn., Wien, 18. pp. 537–540, Nov. 4, 1900.)—This apparatus com-

prises a vertically arranged solenoid having five coils, of which two are connected in the armature circuit of the dynamo, and two or all of the others are connected as a shunt to the armature. In the interior of the solenoid works an iron armature core suspended from one arm of a pivoted balance beam, from the other arm of which is suspended a vertical bar; the core and bar bear at their lower ends a series of bridge-pieces adapted to dip into correspondingly arranged mercury cups when the armature core is raised or depressed. The system is normally held with the bridge-pieces out of the cups by means of two spring-pressed arms acting on opposite sides of a roller on the vertical bar. When the pressure at the dynamo terminals reaches a predetermined value, the bridge-pieces are moved up or down to complete the armature circuit, whereupon the series coils on the solenoid are energised and the contact thus made secure. The apparatus is adapted for use in connection with Dick's system of railway train-lighting. (See Elektrotechn. Zeitschr. 1898, Heft 17; and Zeitschr. f. Elektrotech. 1899, Heft 12 and 13.) The paper is illustrated by diagrams and photographs. C. K. F.

704. *Electromagnetic Clutch.* **J. Löwy.** (Zeitschr. Elektrotechn., Wien, 18. pp. 623–624, Dec. 23, 1900.)—This simple form of electromagnetic clutch is in use for driving light lathes in the k.k. Staatsgewerbe Schule at Vienna, and comprises an annular electro-magnet E keyed on to the driving shaft W and supplied with current through brushes sliding on insulated contact-rings



$r_1 r_2$. Each polar flange of the channel-shaped core is divided into teeth as shown. The magnet E fits into the stepped cone w, from which the lathe is driven, the cone w being capable of turning freely on the shaft W, except when the magnet E is energised. The magnet is wound to 430 ohms, and takes 0·2 ampere at 85 volts. C. K. F.

705. *High-Tension Switch.* **J. Froitzheim.** (Elektrotechn. Zeitschr. 21. pp. 977–979, Nov. 22, 1900.)—This paper describes a switch gear for use with the Helios three-phase generator at the Paris Exhibition. A cast-iron column bears a dial with eight instruments, and before this stands a second small column, with central wheel actuating the main switch, and side ratchet levers for adjusting the generator's and its exciter's field resistances. The three-

phase high-tension switch is placed below the floor, carrying the switch-column, and besides being actuated by hand is provided with an automatic device to open the switch in case of excess of current. Its novelty consists in the application of an air-blast to blow out the arc on breaking contact. Air is supplied at a pressure of 20 atmospheres by a pump worked by a three-phase motor, which is automatically switched on and off by a piston acted on by the air pressure and controlled by a spring. G. H. B.

706. *Water Resistance.* **W. E. Warrilow.** (Elect. Rev. 47. pp. 1011–1012, Dec. 28, 1900.)—The author discusses the use of large units in electrical power stations, and describes with illustrations a cheap and effective water resistance for large powers. An iron tank is used, 8ft. × 4ft. × 3ft. 3in. deep, with water supply laid on ; one electrode consists of strips of lead carried on wooden beams, while the tank is used for the other. The beams are raised and lowered by a wire rope, insulated from them, and led over pulleys into the engine-room, where it is attached to a screw gear, by means of which the resistance is adjusted. A pointer moving over a scale indicates roughly the value of the resistance. The resistance is fixed on the roof of the station, and has carried 600 kw. successfully with the electrode only one-quarter immersed, the water being kept running all the time. The total cost was about £30, exclusive of cables. A. H. A.

707. *Action in Cable Dielectrics.* **G. Rheins.** (Comptes Rendus, 131. pp. 505–506, Sept. 10, 1900.)—When a cable undergoes alterations of electrical pressure it preserves intact all its qualities, electric and organic. If the pressure is always in the same direction it loses its qualities one by one in an order which is always the same, viz. : (1) Self-induction ; (2) capacity ; (3) insulation ; (4) conductivity. This action is due to the slow penetration of the metal of the conductor through the dielectric : it is independent of the material of the dielectric, being found in both gutta and (impregnated) paper. A gutta-covered cable which has been in use twenty years will be found to have copper in the outside layers of the insulation ; a paper-covered cable in use four years was found to show penetration of copper only to the inner layers. The cause of the penetration is obscure. M. O.'G.

708. *Ships' Telegraphs.* **G. Dary.** (Électricien, 20. pp. 401–406, Dec. 29, 1900.)—This is a description of apparatus for transmitting orders from the bridge to other parts of a ship, and acknowledging their receipt. It consists in principle of a multiple-core cable connecting corresponding points of a transmitter and receiver. When a signal is transmitted, a bell rings, and a lamp is lighted at the corresponding points of both instruments, while upon repeating the signal at the receiver the bells are stopped and the lamps extinguished, thus indicating that the order has been received. The receiver may be mechanically connected with the machinery to which the order refers, so that upon carrying out the order the signal is automatically repeated at the transmitter. A speed annunciator and a rudder telegraph of similar type are also described. It is suggested that as the cessation of the indication due to an interruption of the line could not be distinguished from the acknowledgment signal, it would be better to perform the function of the latter by causing the bell to ring instead of by stopping it. The apparatus has been fitted on several French warships and merchant steamers.

A. H. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

709. *Effect of Wave-Shape on Core Loss in Transformers.* **G. Benischke.** (Elektrotechn. Zeitschr. 22. pp. 52–57, Jan. 17, 1901.)—It is usual to assume that the total iron loss may be represented by means of the formula—

$$L = \eta n B^{1\cdot6} + \beta n^2 B^2 \qquad (1)$$

in which n is the frequency, B the maximum induction, and η and β two constants. It has been known for some time that η is not quite constant, but varies with B. Now if we assume that B is maintained constant, but that the frequency and the wave-shape are varied, then there arises the further question as to whether η and β also vary with frequency and wave-shape. The author's elaborate research deals with this problem. Three widely different wave-shapes, which we may call I, II, and III, were used. These were all obtained from the same three-phase generator, by varying the coupling of the three phases. Wave I was that corresponding to a single phase, and was highly peaked, as the following harmonic analysis shows :—

$$e_1 = 61\cdot6 \sin pt - 17 \sin 3pt - 0\cdot87 \sin 5pt - 1\cdot06 \sin 7pt + 1\cdot06 \sin 9pt.$$

Wave II, which corresponded to that between two terminals of the machine, the phases being coupled star fashion, was practically a pure sine wave ; while wave III, obtained by reversing the connections of one of the phases between the terminals used, was a flat-topped wave with two well-marked humps—

$$e_3 = 62\cdot9 \sin pt + 31\cdot1 \sin 3pt.$$

The harmonic analysis of the waves afforded a means of determining their amplitude factors (ratio of r.m.s. to maximum value). Further, an integration of the waves gave a means of finding the corresponding waves of magnetic induction, and their amplitude factors ; from which the r.m.s. values of the p.d. corresponding to the same value of B for each of the three waves could be found. The ring experimented on consisted of discs 0·5 mm. thick, having an external diameter of 30 cm., and an internal diameter of 24 cm. The cross section of the ring was 8·85 sq. cm., and it was uniformly wound over with 300 turns. The value of B chosen was 10,000. Using wave I, the following set of readings was obtained (B = 10,000 throughout) :—

Volts.....	40·35	53·75	60·4	66·2	73·43	80·63	41·13	47·9	61·78
Watts	14·46	20·96	24·54	28·4	32·33	35·93	14·82	18·3	25·48
Frequency	30	40	45	50·2	55·5	60·1	30·7	35·7	46·3
Watts per period ...	0·482	0·524	0·546	0·566	0·583	0·598	0·483	0·509	0·550

If equation (1) be divided throughout by n, we get $\frac{L}{n} = \eta B^{1\cdot6} + \beta n B^2$, so that for a given B the watts per period will be a linear function of the frequency if the equation is correct. When the results given above are plotted, however, it is found that the curve is not quite straight, but concave towards the axis of frequency. The author considers this effect from the theoretical point of view, and shows that it is due to the screening action of

the eddy-currents in the core plates. If the plates are very thin we should expect the screening action to be negligible, and the straight-line law to hold. This the author found to be the case with plates 0·25 mm. thick for frequencies up to 60. Using the results tabulated above, and drawing a straight line through the points corresponding to frequencies of 35 and 55, and repeating the process for waves II and III, the author arrives at the following results :—

Wave.	Amplitude-factor of e.m.f. Wave.	Amplitude-factor of Magnetic Induction Wave.	η	$\beta \times 10^7$	$\beta \times 10^7 \times$ Amplitude-factor of e.m.f. Wave.
I	0·568	0·775	0·00199	5·42	3·06
II	0·707	0·707	0·00193	4·52	3·19
III	0·735	0·613	0·00186	4·19	3·07

From this it appears that both η and β decrease (for a constant value of B) as the amplitude-factor of the e.m.f. wave increases. The hysteresis loss is greater for flat-topped waves of magnetic induction than for peaked ones of the same amplitude. Further, the product of the eddy-current coefficient β and the amplitude-factor of the e.m.f. wave is approximately constant.

A. H.

710. *Transformer Design.* **H. C. Wirt.** (Journal of Electricity, S. F. 10. pp. 42–45 ; Discussion, pp. 45–47, 1900. Paper read before the Electrical Transmission Convention.)—The transformers made by the General Electric Company (N.Y.) are tested at 10,000 volts when intended for working pressures of 3,000 volts or less. The temperature rise of oil-insulated transformers should not exceed 60° C. (by resistance) after an eight-hour run at full load. Indeed a rise of 45° C. is a better limit. Higher temperatures cause appreciable increase in core loss. Out of 20,000 transformers installed during the previous eighteen months, only 10 had been returned for repairs owing to defects in the insulation. The requirements of high insulation and low temperature are more easily satisfied with the core type of transformer than with the shell type. Temperatures obtained by thermometer may in some cases be 50° C. lower than the actual temperatures, as measured by increase of resistance, especially in the shell type. Earth shields are seldom used, the secondary being earthed instead. W. H. E.

REFERENCES.

711. *Compounding Alternators.* **M. T. Gentile.** (Elettricità, Milan, 19. pp. 739–741, Nov. 24, 1900.)—The author treats the subject theoretically, making the assumptions that the current follows a sine-law, and that in actual machines the magnetic induction is sensibly proportional to the magnetising force. He arrives at an expression for the value of the exciting current, in terms of the current and e.m.f. of the alternator, and of some constants depending on its magnetic circuit and windings. G. H. B.

712. *Separation of Hysteresis and Eddy-Current Losses.* **H. Kamps.** (Elektrotechn. Zeitschr. 22. p. 111, Jan. 31, 1901.)—A letter commenting briefly on Benischke's paper (1901, Abstract No. 709) on this subject. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

713. *Power Distribution in Small Installations.* **H. A. Earle.** (Inst. Elect. Engin., Journ. 30. pp. 308–322; Discussion, pp. 322–325, Feb., 1901. Paper read before the Manchester Section of the I.E.E.)—This paper deals mainly with the relative advantages of direct and polyphase motors for small factory installations. The author gives a table showing the weight of copper required in the line on the various systems of distribution by means of direct and polyphase currents, supposing that equal power is distributed with equal loss in the line in all cases, and that the pressure at which current is supplied to lamps or motors is also the same. The advantage is almost equally divided between the three-wire direct current and the three-phase star systems. With reference to the weights of the generators, the 32-pole three-phase generators on the Central London Railway give 850 kw. at 94 r.p.m.; they weigh about 39 tons, including the exciter. On the other hand, a 10-pole direct-current traction generator, having an output of 900 kw. at 95 r.p.m., weighs 45 tons. Thus, allowing for the slight difference in output, the weights are about the same in the two cases. The polyphase machine is, however, about 10 per cent. cheaper to build, this being chiefly due to the cost of the commutator. At the same time when allowance is made for power factor, the advantage may lie with the direct-current machine. Small polyphase motors are about 5 per cent. cheaper than direct-current ones; but they are about 10 per cent. more expensive with wound rotors for sizes between 10 h.p. and 100 h.p. With regard to the operation of motors under varying conditions, the author holds that the direct-current system is the best, either from the point of view of starting torque, regulation of speed, constancy of speed, or efficiency. The power factors of polyphase motors by different makers appear to vary widely; but from the examination of a large number of cases the following may be taken as fair average values of power factors at full loads, viz. :—

B.H.P.	5	10	15	25	50	100
Power factor	0·76	0·79	0·81	0·83	0·86	0·88

Cases are finally considered where motors are required to run at variable or constant speeds with variable or constant torque, polyphase motors appearing to the best advantage under conditions of constant speed and constant torque. W. H. S.

714. *Concentric Cable Breakdowns.* **S. Hanappe.** (Écl. Électr. 25. pp. 492–502, Dec. 29, 1900.)—Referring to Kapp's important paper on this subject [see Abstract No. 755 (1900)], the author suggests some simple graphical methods of determining the maximum possible p.d. between the outer conductor and the lead sheathing of the cable. In order to take account of the iron loss, he supposes the total primary current split up into a wattless or magnetising component, and a load component. He then constructs the vector diagram for the case of a transformer whose secondary is open, and

whose primary is in series with a capacity, as follows : The *ri*-component of the impressed p.d. is laid off along the vector of total primary current ; the component required to balance the reactance e.m.f. is drawn so as to be in quadrature with the magnetising component of the primary current, and ahead of it as regards phase ; while the component which balances the p.d. across the condenser terminals is in quadrature with the vector of total primary current, and behind it as regards phase. These three vectors when compounded give the primary p.d. vector. Since the *ri*-component is very small, it may be neglected. Using the simplified diagram, the author draws curves, showing how the condenser p.d. varies with its capacity when the primary impressed p.d. is constant. The maximum condenser p.d. is shown to be equal to $V/\sin\alpha$, where $V =$ impressed p.d., and $\alpha =$ angle of phase-difference between the total current and its magnetising component. The results so obtained are applied to the case of a concentric cable supplying a transformer, when the outer conductor is disconnected from the bus-bars before the inner [see Abstract No. 755 (1900)]. The author next applies the graphical method of treatment to the case of a transformer whose secondary is across a variable capacity, while its primary is supplied at a constant p.d. Lastly, the problem of a primary network of concentric cables is considered when there is an earth on the inner conductor. A. H.

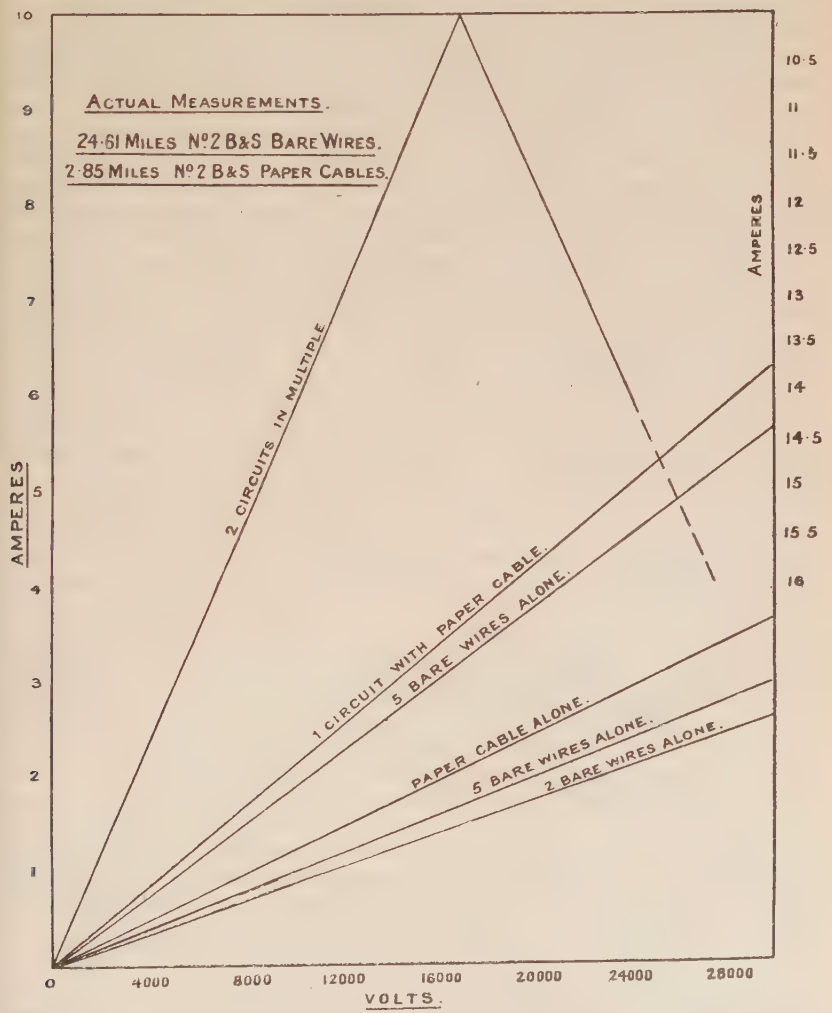
715. *Faults on Electric Wiring.* **G. C. Allingham.** (Elect. Rev. 47. pp. 494–496, Sept. 28, 1900.)—At Guildford, the only place where a concentric system with earthed outer is in use, the outer, which is the neutral wire of a three-wire system, is protected from corrosion by being embedded in bitumen. There is danger of fire in a house from corrosion or breakage of the outer conductor. On any non-concentric metal sheathed system it is possible to blow the fuses on a faultily-wired house by daily earthing the conductors in turn at the supply station. The sheathing must, however, be continuous. Fibre-covered cables have been used in wiring new buildings without protection over the lead and without absorption of moisture by the fibre, though surface leakage is troublesome, as in all metal-sheathed systems, especially when houses are new. M. O'G.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

716. *St. Croix Power Transmission at 25,000 volts.* **H. Floy.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 567–597, Nov., 1900.)—A natural fall of 30 feet was increased to 82 feet by means of a concrete dam. The minimum flow of water yields 2,000 h.p. continuously. The concrete is one part by measure of Portland cement by Alsen and Atlas, three parts sharp sand with four parts stone broken into cubes between 3½ inches and 1 inch side, and consisting of granite trap and gneiss boulders. The open hearth steel penstock is 12 feet in diameter. Four pairs of 36-inch "Victor" turbines are mounted horizontally, each pair being direct-coupled to a 750 k.w. three-phase generator, with a revolving armature separately excited, giving 800 volts and 60 cycles when running at 300 r.p.m. The water-wheel governors are an improved Giesler pattern, and allow only a 3 per cent. variation for 25 per cent. variation of lead. They are electrically controlled by the 125-volt exciter current.

The No. 2 B & S medium hard-drawn copper conductors are carried on "Provo" triple petticoat glass insulators 7 inches in diameter, mounted on

locust pins boiled in paraffin. The line is level irrespective of the configurations in the earth's surface. It commences in a brick lightning arrester house abutting on the power house containing choke coils and arresters. Where an iron bridge is crossed the two parallel three-phase circuits are spiraled, in addition to which one circuit is spiraled twice relatively to the other. There are three miles of two three-conductor lead-covered cables connecting the



lightning arrester house with the distributing substation; they are drawn into four-hole McRoy vitrified clay conduits in concrete. One cable is rubber and the other paper; each conductor has 66,000 circular mils; there are 7 strands, and the lead sheath is $\frac{1}{8}$ inch thick, making the cable $2\frac{1}{4}$ inches outside diameter. The paper cable has $\frac{9}{32}$ inch insulation on each wire, $\frac{4}{32}$ inch enveloping jacket, covered by lead, which is tinned externally. The rubber cable has 35 per cent. pure Para compound, $\frac{7}{32}$ inch thick, wrapped with drilled tape round each conductor. The jacket is $\frac{5}{32}$ inch thick, and is

followed by the lead, which contains 3 per cent. of tin. The cables are tested to 40,000 volts, and are guaranteed for five years to withstand 30,000 volts. This experiment will show whether the rubber or paper under similar conditions will prove the more durable. The total resistance of each conductor from generating to distributing station is 23 ohms, the drop of volts is 3,000, and with a 90 per cent. power factor and 25,000 initial volts this gives 7·7 per cent. loss when using both lines in parallel.

The high-tension bus-bars and their taps to the high-tension switches, &c., are single conductors covered with ¼-inch Para compound rubber, laid in conduits of wood pulp indurated with asphalte guaranteed to stand 20,000 volts. The triple switches will break 50 amperes at 25,000 volts under oil.

There are two banks of static transformers, each consisting of three 22,500 to 78-volt three-phase to six-phase transformers, and two banks of two 22,500 to 2,100 oil cooled 200 kw. three-phase to two-phase transformers. Each of the 300-kw. transformers has a single winding on the primary and two distinct windings on the secondary. By connecting three of these in a set three-phase to six-phase transformation is effected. A decided increase in the capacity of the rotaries is thereby effected.

Switchboard diagrams are given. The cables were tested by raising the volts to 30,400. The charging current to one of the three-conductor overhead lines, to two of the three conductors, to the three-conductor line connected to the paper cable, and to the two three-conductor overhead lines connected respectively to the two cables, both circuits being in multiple with one another and supplied with three-phase current, gave the accompanying curves connecting voltage to charge current. For convenience in the diagram the curve for two circuits in multiple is shown as a broken line, the scale on the right-hand side referring to the second part. It will be noticed that the charging current for two wires in the three-phase circuit is appreciably less than when the voltage is applied to all three conductors. M. O'G.

717. *Electric Lighting of Thonon and Évian.* **J. Bordeaux.** (Ind. Élect. 9. pp. 521–525, Dec. 10, 1900.)—*System.*—Hydraulic power station, generating three-phase current at 3,300 volts and transmitting to transformer substations at Thonon, 14 km. distant, and Évian, 22 km. distant. Distribution at 100 volts.

Power is taken from the river Dranse. The canal, constructed in masonry, is 800 m. long, and feeds a reservoir, from which a pipe of sheet-iron, 1 m. in diameter, supplies the turbines. The canal gives 2 cubic metres per second at a head of 52 metres.

Power-house.—Three turbines are installed of 300 h.p. each, by Picard-Pietel, of Geneva. These drive through flexible insulating couplings three Oerlikon three-phase generators, giving 60 amperes per phase at 3,300 volts when running at 430 r.p.m. Their exciters are fixed on the main shaft.

Distribution.—Two overhead lines transmit current to Thonon and Évian, each consisting of four wires, one per phase and a neutral wire. On the low-tension network, at 100 volts, the lamps are connected between each wire and the neutral wire. G. H. B.

718. *Ekaterinoslaw Tramway.* **G. Orban** and **K. Winkler.** (Soc. Belge Élect., Bull. 17. pp. 461–482, Nov., 1900.)—*System.*—Overhead trolley, continuous current at 550 volts. *The boiler-house* contains four water-tube boilers by Fitzner and Gamper de Sielce ; three have a heating surface of 190 sq. m. and 44 tubes 88·5 mm. in diameter ; the fourth has a heating surface of 230 sq. m. and 131 tubes of the same diameter. The four boilers together

will deliver 9,000 kilos of steam per hour as a maximum, at a pressure of 9½ atmospheres. Water is obtained from the river Dniéper, a pumping station being erected at a distance of 800 m. from the station ; the pumps are driven by two 30-h.p. electric motors. The feed-water is heated by the exhaust steam from two Worthington feed-pumps. The coal is stored in bunkers containing 320 tons, and is fired by hand.

The engine-room contains four compound engines by Tosi. These are of the vertical type with piston valves, and indicate 200 h.p. with a pressure of 8 atmospheres when running at 180 r.p.m. The cylinders are 400 and 600 mm. in diameter. The fourth engine is a tandem horizontal, indicating 350 h.p. at 8½ atmospheres, running at 110 r.p.m. ; the cylinders are 450 and 750 mm. in diameter. Four dynamos are coupled directly to the engines ; they are multipolar compound-wound machines, generating at 580 volts ; three are of 145 kw. each, and the fourth of 300 kw.

There are three tramway lines, the principal one, 6 kilometres long, being laid with double track ; except for two of 8 per cent. and 5 per cent. respectively, the gradients do not exceed 3 per cent. Vignoles rails, weighing 30 kilos per metre, are laid on oak sleepers placed 1 metre apart ; they are bonded with Chicago-type bonds, and form the only return circuit. The overhead construction is carried out, where possible, by span wires attached to the houses, and elsewhere by wooden poles carrying iron brackets. The trolley wire is of silicium-bronze, 8·3 mm. in diameter, and is supported by Aetna insulators and mechanical ears.

The line is supplied by two feeders carried on the trolley-wire poles ; one, 250 m. long, has a section of 53 sq. mm., and the other, 3,000 m. long, of 265 sq. mm.

The motor cars are 26 in number, 17 closed and 9 open ; they weigh complete 7·5 tons, and have a capacity of 16 passengers seated and 14 standing. Each is equipped with two 30-h.p. Schuckert motors, running at 550 r.p.m., with reduction gear of 1 to 5. There are also 25 trailers, each weighing 2·3 tons and carrying 36 passengers. The normal speed of the cars is 12 kw. per hour. Each car travels on the average 160 km., and carries from 5½ to 6 passengers per kilometre. The consumption of coal is from 2·2–2·4 kilos per car-kilometre. The paper includes a diagram of the switchboard and several photographic views. G. H. B.

719. *Rochester and Sodus Bay Electric Railway.* **T. J. Nicholl.** (Street Rly. Journ. 16. pp. 883–885, Oct., 1900. Paper read before the New York State Street Rly. Association, Sept., 1900.)—*System*. Three-phase current, generated at 380 volts, transmitted at 10,000 volts, and converted to direct current at 600 volts. The *boiler-room* contains four 250-h.p. Taylor and Altman water-tube boilers. The *engine-room* contains two horizontal cross-compound Corliss engines, of 500 h.p. each. Each engine drives directly a three-phase generator of 300 kw. capacity, generating at 380 volts, 25 cycles per second. Six 100-kw. stationary transformers in the station raise the pressure to 10,000 volts for transmission to two substations. There is also a rotary converter in the station, receiving alternating current at 380 volts and feeding the western section of the railway with direct current at 600 volts. The transmission line consists of three No. 1 bare copper wires 18 inches apart, at the corners of an equilateral triangle. The substations are 12 and 24 miles from the generating station ; each contains three step-down transformers and one 250-kw. rotary converter. Distributors of No. 0000 gauge run three miles each way from the converters ; the trolley wires are divided into six

sections, joined by circuit-breakers. The station is equipped with high-pressure oil-break switch-gear and special time-limit circuit-breakers. The track is equipped on the overhead trolley system. Wooden poles, 30 to 40 feet long, and spaced about 110 feet apart, carry, by means of bracket arms, two No. 00 figure-8 copper wires. The high-pressure line runs across country away from the railway, and is also carried on wooden poles, with porcelain insulators. The rails are of both T and girder type, 60 lbs. per yard, tied together by wooden ties. The fishplates are 24 inches long, with 4 bolts, and the joints are bonded with a No. 0000 copper bond 8 inches long. The foundation of the track is local ballast and gravel. The track is single, 39 miles long; a length of 13 miles runs over private right-of-way. The heaviest gradient is 5 per cent., and the sharpest curve has a radius of 100 feet. A turnout is provided in every mile of track. There are 18 passenger and combination cars, 45 feet long, each fitted with four G.E. 57 or G.E. 1,000 motors, and carried on Taylor radial trucks, as well as four 26-feet motor cars and six 26-feet trailers.

The capital outlay was about £144,400, as follows: Track, line, right-of-way, &c., £90,600; machinery and buildings, £26,800; car equipment, £23,000; organisation expenses, £4,000. One train is run each way every hour from 6 a.m. to 9 p.m. The line is divided into 13 fare limits of 2½d. each. The full distance is covered in 2 hours 50 minutes, including 50 stops. A. H. A.

720. *Electric Equipment of the Wansee Railway, Berlin.* **R. Rinkel.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1198–1209, 1900.)—A description is given of the third-rail railway equipment which was carried out by Siemens

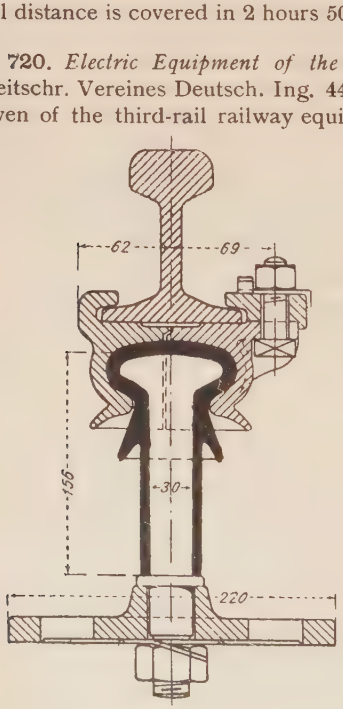


FIG. 1.

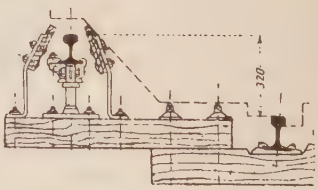


FIG. 2.

and Halske between Berlin Wansee station and Zehlendorf station. The motors, of which there are three to each motor car, are mounted direct on the axles, the top and bottom poles being consequent so as to get the necessary clearance between the bottom of the motor and the road-bed. The conductor rail is fixed some distance above the track rail and is insulated by a

hard rubber composition as shown in Fig. 1. The conductor-rail is protected by boards carried along each side as shown in Fig. 2. The dynamo gives 450 amperes at 718 volts, and there is a large battery at each end of the line.

E. K. S.

721. *Electric Lighting of the SS. "Deutschland."* (Engineering, 70. pp. 723–724, Dec. 7, 1900.)—The generating plant consists of three steam-dynamos of 700 amperes each, and two of 400 amperes each, at 110 volts, running at 250 r.p.m. The engines are of the vertical compound type, direct coupled to the dynamos. There are 1,500 25-c.p. lamps, and 1,550 16-c.p. lamps, 70 connections for small ventilators, and 375 for curling-irons. The power circuits supply 23 motors of 50 h.p. in all, 8 stoves, and some small apparatus. There are three main circuits—for "police" lighting, including all the lamps essential to safety, general lighting, and power. Provision is made for connecting any circuit with any dynamo. The conductors are insulated with vulcanised rubber. Indicators in the steering-house show whether the signal lamps are alight or not. The installation was carried out by the *A. E. G.* Diagrams of the switchboard and light and power circuits are given. A. H. A.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

722. *Recording the Tractive Force and Acceleration of Trains.* **A. Mallock.** (Engineer, 90. p. 323, Sept. 28, 1900. British Assoc. Report (1900), pp. 877–878.)—The author uses a short pendulum whose free vibrations are adequately damped which hangs in a direction due to the resultant of gravity and the acceleration which the bob at the time experiences : hence the angle which the pendulum makes with the vertical is a measure of the acceleration at each instant. On a frictionless train moving under gravity along any series of gradients the pendulum will always hang normal to the line. The angle which the pendulum makes with a fixed direction of the carriage gives a measure of the horizontal force acting on the carriage independently of gravity and is equal to the motor tractive force, or the resistance. It is noted that when going round a curve, if each carriage supplies its own motive force at the expense of its kinetic energy, the whole of the sideways force which is required to keep the train on the curve is supplied by the pressure of the rails on the wheel flanges. If the motive force is transmitted from a motor at one end of the train the angle which each carriage makes with the one behind it gives rise to a couple which lessens the pressure between the rail and flange.

A curve is given showing the record of a steam locomotive starting a 100-ton train ; also of direct-acting electric motors working on a 180-ton train, the application of brakes, and the gradual bringing to rest of the train by the effect of resistance. M. O'G.

723. *Measurement of Tractive Force on Tramways.* **G. Kapp.** (Elektrotechn. Zeitschr. 21. pp. 579–580, 1900. Paper read before the 8th Jahresversammlung des Verbandes Deutscher Elektrotechniker in Kiel.)—The author proposes a method of measuring the tractive force exerted on a car, by a manometer consisting of a long tube, fixed horizontally in the car, and bent vertically upwards at each end. This, if filled with liquid, will show on a vertical scale the tangent of the angle of inclination of the car, which, neglecting the difference between the sine and the tangent of the small angle, is a measure of the tractive force due to the gradient.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

Again, an acceleration of the car will produce a difference of level in the two liquid columns, proportional to p/g, where p is the acceleration of the car. The author gives calculations showing that the difference in level of the liquid columns is proportional to the total tractive force due to gradient and to acceleration, within a maximum error of 1 per cent.; he points out, however, a possible source of error due to unequal loading of the car-springs, which may give the car-body an inclination relatively to the rails. The tractive force due to rolling and other friction may be determined by a measurement made on a level track, while the car is slowing down, without applying brakes.

The author employs a tube 50 cm. long filled with mercury, with an indicator tube of 5 mm. bore filled with water; with this, readings can easily be made to within $\frac{1}{2}$ kg. per ton. The results are given of some measurements made by the author with this instrument on the Berlin tramways and the Lichterfeld railway. G. H. B.

724. *Permanent Way for Electric Traction.* **H. R. Hooper.** (Tram. Rly. World, 9. pp. 586–589, Dec., 1900.)—Generally speaking, permanent way costs £6,000 per mile of single track, or, roughly, about one-third of the total capital expenditure on an electric tramway. Its life is much shorter than that of any other branch of traction work and may be generously taken at an average of ten years. This means that every year £520 per mile of single track must be earned over and above all fixed charges and maintenance to form a sinking fund at 3 per cent. for permanent way alone. Once let the permanent way get into a bad state and the general repairs on rolling stock and the coal bill rise together in alarming proportions. On a steam railway the rails supported on sleepers act as girders and yield under the live loads, but with electric traction the rails are supported evenly throughout their length, and tensible strength is of little consideration and hardness becomes the dominant factor. The lowest tender for rails is by no means the cheapest, for an increase of 10s. per ton on a mile of single track with 90-lb. rails means only £70, whereas if the better rail increases the life of the permanent way for one single year a saving of £520 is effected. At the present time rails can be obtained of about the following chemical analysis: Carbon 0·45 to 0·55 per cent., silicon 0·06 to 0·08 per cent., phosphorus 0·06 to 0·08 per cent., sulphur 0·05 to 0·06 per cent., manganese 0·80 to 1·00 per cent., and this composition gives a fairly good rail, but efforts should be made to produce greater hardness. The usual chilled cast-iron wheels rapidly wear out the rails, and owing to the narrowness of the groove in this country, the life of such wheels is only one-third of what it is in America. It is therefore possible that in this country the more expensive tyred wheels would be economical.

Fishplates should be 24 to 30 inches long, and have six or eight 1-inch steel bolts, which should be checked with a cold sett after the fishplates have been screwed on as tightly as possible. Cement, mortar, or pitch is only effective for a few years in preventing the nuts from turning. Sole plates under joints are not to be commended. Rails should be laid with butt joints, for in paved work they do not creep from contraction or expansion. One of the secrets of getting a good permanent way is to have the rails delivered on the site perfectly straight and true. This is more possible with 45-feet rails than with 60-feet rails. For a sett 5 inches deep, the rail should be $6\frac{1}{2}$ inches high so that the concrete can be brought over the bottom flange to seal the packing under the rail, and hold it to gauge. Tie-bars should be of wrought iron 2 inches by $\frac{3}{8}$ inch.

Concrete is usually 6 to 1, but if laid in ordinarily fine weather, 7 to 1 is ample. Setts should be fitted as closely as possible against the rails, and joints should not exceed ¾ inch ; a pitch grout to within ½-inch of the top forms the best joint, as it prevents surface water soaking through to the bed of concrete. Experience shows that Jarrah wood blocks, though exceedingly hard, require more care in laying and subsequent watching than softer woods, and their expansion is quite sufficient to affect the gauge. The question of using inserted manganese steel plates on the wearing parts of points and crossings deserves attention. The angle at points and crossings should not exceed a maximum of 1 in 8, but if too easy, the taper becomes too long. E. H. C.-H.

725. *Surface Contact System of the Helios Company.* **J. P. Doflein.** (Elektrotechn. Zeitschr. 21. pp. 924–926, Nov. 8, 1900.)—Description of a surface contact system which is under trial by the Helios Elektricitäts A. G. Two studs are placed side by side at intervals, and six of these pairs of studs are connected to a circular box by the side of the track. This box is neatly designed, and contains the solenoids which make and break connection as the car moves over the studs. E. K. S.

726. *Electric Automobiles.* **R. A. Fliess.** (Elect. World and Engineer, 36. pp. 516–523, Oct. 6 ; 563–566, Oct. 13 ; 599–605, Oct. 20 ; and 635–638, Oct. 27, 1900.)—Tests were carried out on ten vehicles of six different makes. A 31·5 mile run on one charge in a crowded street with two passengers gave the following results :—

Weight of vehicle	3,085 lbs.
Weight of passengers and instruments	305 „
Weight of load carried	nil.
Total weight	3,390 lbs.
Battery equipment	44 cells
Weight of battery	1,120 lbs.
Ratio of battery weight to total weight of vehicle	36·3 per cent.
Ratio of battery weight to total weight causing draw-bar pull	33 „
Total distance covered during test	31·51 miles
Total time in motion during test	3 hr. 23 m. 35 sec.
Average speed while in motion	9·28 miles per hour
Average watt-hours used [on car] per car mile	155·27
Average watt-hours used [on car] per ton mile	91·6
Total watt-hours used on trip	4,892·8

It was found that 90 watt-hours per ton mile was a fair average, but this could be reduced to 80 watt-hours per ton mile by the use of ball bearings, the vehicles having solid rubber tyres. On adding a load to two vehicles, it was found that the watt-hours per ton mile remained the same for each. The author favours for commercial purposes the lightest vehicle that can be used. Pneumatic tyres show a slight increase of power consumption over solid tyres. The tests were taken for the most part over good asphalte in ideal weather. Over macadam the power consumption went up to 116 watt-hours per ton mile. In heavy rain, wind, and in five inches of snow and

slush the average power was 114 [*sic*] watt-hours per ton mile, under "the most trying conditions a car will ever be called upon to contest."

A pleasure vehicle was tested as follows :—

Weight of vehicle	1,165 lbs.
Weight of passengers and instruments	305 „
Total weight	1,470 lbs.
For a distance of	3·31 miles
Average speed while in motion	9·68 miles per hour
Average watt-hours used per car mile	63·32
Average watt-hours used per ton mile	86·14
For a distance of	2·35 miles
Average speed while in motion	6·79 miles per hour
Average watt-hours used per car mile	73·53
Average watt-hours used per ton mile	100·04

The battery efficiency when in good order was found to be 68 per cent. Twelve tests on four carriages over the same ground are summarised below :—

Distance covered in miles.	Speed in miles per hour.	Watt-hours used.	Watt-hours per car-mile.	Watt-hours per ton-mile.	Weight causing Draw-bar pull.	Time in motion. Min.
2·62	10·14	404·4	188·7	83·11	4525	15·5
2·67	10·68	489·6	183·37	81·02	4525	15
2·57	9·44	414·4	161·24	80·31	4015	16·25
2·61	11·18	396·8	152·03	81·87	3714	14
2·64	11·31	342·4	129·69	69·83	3714	14
2·63	10·52	336	127·75	68·79	3714	15
2·52	10·8	356·8	141·58	83·52	3390	14
2·54	9·83	353·6	139·22	82·13	3390	15·5
2·55	10·31	339·2	133·02	78·41	3390	14·8
2·55	10·93	328	128·62	75·88	3390	14
2·56	10·24	384	150	89·42	3355	15
3·31	9·68	209·6	63·32	86·14	1470	20·5

The author concludes that 22 miles on one charge at an average speed of 8·5 miles per hour in crowded streets, with a maximum consumption of 115 watt-hours per ton mile with an average battery efficiency of 70 per cent., may be obtained if the running voltage is not allowed to drop below 1·75 volts per cell.

From a large number of observations in Manhattan, delivery vans are in motion less than 25 per cent. of the elapsed time, the average speed being 7 miles an hour. From elaborate investigation the longest distance covered by a two-horse van was 21 miles, the time being 8 hours 10 minutes, but the average speed was 2·82 miles per hour.

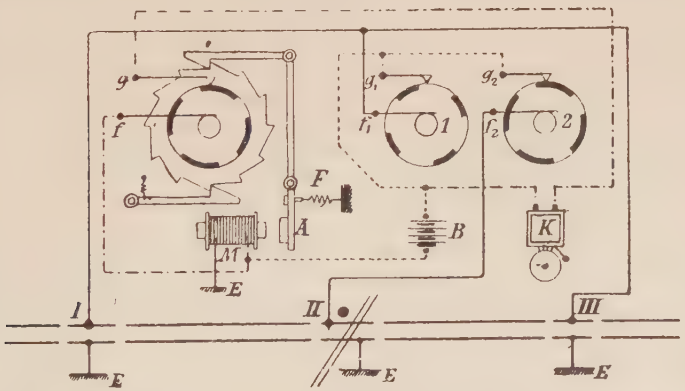
On the average, taking 16 miles as the distance travelled, 50 lbs. as the pull exerted, and 7 miles per hour as the speed while in motion, a horse does 4,356,000 foot-lbs. of work a day. As a final comparison the author makes a saving of 25 per cent. in favour of the automobile, but when allowing for depreciation, 25 per cent. is shown in favour of the horse when an electric vehicle and a horse are required to do the same amount of work.

When, however, the advantage of the greater speed allows the electric vehicle to do its maximum work per day, the economy in favour of the horse is reduced to 1 per cent.

M. O'G.

727. *Electric Delivery Van Equipment in New York.* **M. Loewenthal.** (Elect. World and Engineer, 36. pp. 987–990, Dec. 29, 1900.)—A description of the various electric vans made for, and in use by, a large dry goods establishment during the past three years. The latest form is a truck which is 14 feet long, weighs 6,000 lbs., is fitted with 44 cells having 160 ampere-hours capacity, and is propelled by two 2-h.p. Westinghouse motors. This truck makes a six-mile journey twice a day, and is capable of running 20–30 miles on one charge ; it is designed to run at a speed of 7 to 8 miles an hour, and to carry four persons in addition to a load of 2 tons. Full particulars of the special charging facilities, which have been provided, are given, and the author states that this equipment has already proved electric vehicles of this kind to be a commercial success, provided that they are properly handled and cared for. Illustrations of the vehicles and of the charging plant and "stable" accompany the article. A. G. N.

728. *An Improved Form of Langbein's Train-Signalling Apparatus.* **F. Blacizek.** (Zeitschr. Elektrotechn., Wien, 18. pp. 622–623, Dec. 23, 1900.)—This improvement on Langbein's system of signalling (see Zeitschr. Elektrotechn., Wien, 13. pp. 641–645, 1895), renders it capable of working, although somewhat imperfectly, even if one or more of the fixed contacts on the permanent way fail, the failure making itself known by the continued ringing of the bell, thus enabling the attendant at the station to readjust the



apparatus. The system is shown diagrammatically in the accompanying diagram, with the apparatus in its normal position.

On the train reaching I, the circuit of the electromagnet of the feed-mechanism is momentarily completed at f_1, g_1, and the contact discs turned through an angle corresponding to one tooth, whereupon the bell circuit is completed at g, f. On the train reaching II, the discs are again turned through an angle corresponding to one tooth, and the bell-circuit interrupted. On the train reaching III, the discs are again turned, so as to restore the initial conditions ready to commence a fresh cycle, one revolution corresponding to four cycles. It will be seen that if the connection is not made at I, the bell will not ring till III is reached, when it will remain ringing. If II fails, it will also continue to ring, since III acts similarly to I. If III. fails, the fault will not appear until the passage of the next train, after which the bell will continue ringing. C. K. F.

729. *Electrically-Controlled Bolt-Lock for Railway Points.* **J. Schnatter.** (Zeitschr. Elektrotechn., Wien, 18. pp. 601–604, Dec. 9, 1900.)—In this arrangement a bar, which is connected by a link to the switch or sliding rails, passes through a cast-iron box, and is provided in this box with three recesses. Two of these recesses lie, in each of the positions of the bar, opposite to two hinged bolts moving in opposite directions and provided with weighted levers which normally hold the bolts out of engagement with the recesses. These weighted levers are connected to a vertically sliding rod in such a manner that the bar is locked on raising the rod by hand. The sliding rod is held in its raised position by a detent engaging with the upper one of two pawls mounted respectively on the arms of a pivoted ∩-shaped lever bearing a polarised armature. This armature is arranged near the poles of an electromagnet, so that, by sending an alternate current through the electromagnet, the pawls will be oscillated and the rod allowed to fall, thus permitting the weighted arms to unlock the bar. Three pairs of contacts are also provided which are completed respectively when the rod is in its raised position, *i.e.*, when the bar is locked, and when the bar is in each end position ; these contacts enable the positions of the parts to be determined from the signal-box at any time. The original paper is illustrated by drawings and diagrams. C. K. F.

730. *Price's Friction Car Brake.* (Electrician, 46. pp. 318–320, Dec. 21, 1900.)—Instead of the brake-levers being applied by a chain wound on a barrel by hand-power, the chain in the Price brake is wound on a barrel mounted on the axle and driven by it through a friction-clutch. It is claimed that the faster the wheels are moving the quicker can the brake be applied, and the force of application can be enormous, while at the same time the driver can gauge, by the slip of clutch, the exact amount of action desired, and can thus avoid skidding of the wheels. Comparative tests of power-brakes on the Brooklyn Heights Electric Tramways in the presence of the various makers' representatives gave results which were superior to those obtained with air-brakes. [See also Abstract No. 586 (1901).] E. H. C.-H.

731. *Storage Batteries for Tramway Power Stations.* **H. H. Norris.** (Street Rly. Rev. 10. pp. 733–736, Dec., 1900. Paper read before the New York State Street Rly. Association.)—During the last two years storage batteries have been widely adopted in traction stations to take up the fluctuations of load. In a number of well-known plants, having a total station capacity of 43,560 kw., the batteries installed had a total capacity of 28,560 amperes for one hour, or an average capacity of $\frac{2}{3}$ ampere-hour per kw. output at the discharge rate mentioned. From the daily records of the Buffalo Railway Company's plant for the month of March, 1900, it was found that in 31 days the battery received 189,369 ampere-hours, and gave out 164,036 ampere-hours, which is an efficiency of 86·6 per cent. as to ampere-hours. The same plant was elaborately tested by the Sibley College students [see Abstract No. 294 (1901)], and the results showed that more steam and more coal are consumed per i.h.p. when the battery is not in operation than when it is. E. H. C.-H.

732. *Protection of Telegraph and Telephone Lines against High Potential Currents.* **Piérard.** (Soc. Belge Élect., Bull. 17. pp. 279–286 ; Discussion, pp. 286–294, 1900.)—The Belgian Government prescribes that, where practicable, there shall be three guard wires—one in the vertical plane of the trolley wire, the others disposed on either side and in the same horizontal

plane as the first; that these wires shall be attached to insulators, but connected to earth at every post or alternate post. If the telegraph or telephone wires above happen to be parallel to the trolley wire there must be, in addition, transverse guard wires. In the discussion it was stated that practice had shown that an earth connection at the fourth or fifth post was sufficient. But the protective wood lath, or sheath is also in use in Belgium, and is discountenanced by the author as being insufficient and dangerous. Numerous accidents to persons, and to telephones and switchboards, had been caused, and the trolley derailed by this appliance. The lengths of wood are apt to separate at their junctions, the attachments to become loose, and, in damp weather, the wood, even when impregnated before erection, is not a sufficiently good insulator to protect a fallen wire from diverting current. In Brussels a test gave absolute insulation of only 4,500 ohms in damp weather, and in heavy rain the leakage effect would be marked. It is found that a current of only $\frac{1}{3}$ ampere, not enough to melt the fuses, if flowing for some hours, will carbonise the bobbins of telephone bells. Then, again, bronze wire retains spring long after it is erected, and having originally been coiled on small drums, curls up in a spiral when broken, and is thus apt to get round the protector into contact with the naked part of the trolley conductor. These considerations bring the author to favour guard wires. By connecting these to earth a telephone wire which falls across a guard and the trolley wire will become melted by the current, and the end will fall clear. Against the use of guard wires is the additional strain thrown upon the posts, especially upon curves, and, upon existing lines of tramways, the means and appliances for the necessary attachments must be provided. Further, when the trolley wire is accidentally earthed by a slack guard wire, or by coming into contact by flexure, the automatic cut-outs at the central station will cut off the current and arrest the system. To these objections the author replies that the guard wires must be at least 60 cm. above the trolley wire, and that the guards need be only copper wires 3 mm. in diameter. In the discussion the use of guard rings and ramps of metal for telephone and telegraph wires was suggested. These are earthed, and a broken conductor will fall against one or the other and earth itself, and should it also come into contact with a feeder or a trolley wire the apparatus is protected from damage, and the cut-out will come into operation at the central station.

But switchboards at exchanges and subscribers' instruments must also be specially protected from these accidental contacts as well as from lightning. For the former in Belgium, point and paper dischargers are installed near the entry of the lines, and on the same board and consecutive to the dischargers are two platinum wire fuses in glass tubes held in metallic clips: the wire is 5 cm. long and 0·05 mm. in diameter, and fuses after a few seconds when subjected to a current of 0·9 ampere; the annunciator bobbins will support this current for some minutes. In Brussels, however, the fuses are arranged to go with 0·5 to 0·6 ampere. The metal caps at the ends of the tubes are pierced, so that when the fuses are blown the heated air can escape. Similar fuses are employed in the exchanges, but here they are in groups, and are sunk in holes in a board. At the bottom of such a hole is a small metallic cap and spiral spring; the interior cap of the fuse tube presses against this, and a screw plug closes the entrance of the hole, bearing inwardly against the other cap of the tube; the latter is thus imbedded and safe from accidental fracture. A wire passes through the board to the back cap and ends outwardly in an eyelet, and the screw plug socket has a small projection; to these the line and switchboard wires are soldered after leaving the lightning dischargers.

E. O. W.

733. *Trolley-Wire Guards.* **Piérard.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 171–178, Aug. 14, 1900. An addendum to the paper referred to in the preceding Abstract.)—The author controverts the arguments of Pedriali and d'Hoop referred to in Abstract No. 945 (1900), that wooden guards fixed to trolley wires are sufficient protection against dangers from overhead telegraph and telephone wires. Piérard cites several bad accidents caused by the broken wire getting into contact with the metal sleeves fixing the guards, or twisting round the trolley wire when falling, or touching the trolley itself; or else by being dragged along by street traffic and being drawn on to the trolley wire at a defective point in the wooden guards. He also quotes a case in Brussels where the insulation of the wooden guard proved to be only 4,500 ohms. He thinks such a protection quite insufficient. He advocates guard wires vertically above the trolley wires, sufficiently high to obviate possible contact with the trolley, should it leave its own wire. The guard wires should be on insulators at the posts, and put to earth at intervals by the rails with insulated wire. These guard wires need be only light ones, say bronze of 3 mm., or iron of 4 mm. in diameter. E. O. W.

734. *Taylor's Interlocking Electric Switch and Signal System.* **J. R. Cravath.** (Elect. World and Engineer, 36. pp. 404–407, Sept. 15, 1900.)—Two methods hitherto in use for operating interlocking switch and signal plants from a central tower are the manual by rods, chains, wires, and levers, and the electro-pneumatic. In the former there are difficulties by friction and slack, as well as from snow and ice in winter; and in the latter from expense, the presence of moisture in pipes and packings in cold weather, and from the fact that a compressor plant must be kept constantly running to supply waste by leaks. Taylor's system is adopted at the Path Street Depôt in Chicago as well as on other roads. The switches are worked by electric motors geared to a mechanism connected directly to the switch-rods. The only connections between the tower and the switch are the two wires comprising the motor circuit. There is thus better protection from the weather than in the manual or pneumatic systems. It has, moreover, surplus power to overcome snow and ice round the switches. The semaphores and dwarf signals are also worked respectively by motors and solenoids. The source of power is a 60-volt storage battery, charged by a gasoline engine of 2 h.p., with a 1-kw. dynamo. It is found that the electric installation is cheaper in first cost than either of the others, and, of course, economical to operate. Motors at the switches are of 1 h.p., taking usually about 7 amperes at 60 volts, one movement occupying two seconds. In opening a switch the motor, connected to appropriate toothed gear and rods, makes one complete revolution, when the armature connections are automatically reversed. This cuts off current also, establishes a new circuit for again closing the switch when required, and temporarily causes the motor to act as a generator and send back current momentarily to the signal tower to enable the signalman's lever or handle to come "home" in his interlocking machine, and thus affords him indication of the proper working of the distant switch. In connection with the latter an indicator is used on all facing points, so that in case a point is not fully closed, the signals governing the approach to the switch cannot be set to clear. For the dwarf signals the operative solenoid has two windings, the low resistance one being that which pulls up the arm against gravity. Near the end of the movement the high resistance is automatically switched in, and the current thus reduced from 6 amperes to ¼ ampere, which suffices for "holding up." For the semaphore arm the

current is in like manner reduced for "lifting" and "holding up" from 2 amperes for the motor to $\frac{1}{10}$ ampere for a magnetic clutch. When the signalman pulls a handle to throw a switch he cannot at first throw it the full length of its stroke. As soon as the handle has gone far enough to throw the motor circuit, it is caught, and cannot be shoved home to unlock the handle that will give the clear signal until the current from the switch motor acting as a dynamo at the end of its stroke energises certain magnets and releases a bar. The switch must therefore be positively opened or closed before any movement corresponding to it can be completed in the interlocking tower. E. O. W.

ELECTRIC LAMPS AND LIGHTING.

735. *Alternating Current Enclosed Arc Lamps.* **H. W. Hillman.** (Journal of Electricity, S. F. 10. pp. 27–36; Discussion, pp. 36–39, and p. 42, Aug., 1900. Paper read before the Electrical Transmission Convention.)—The author compares arc lamps of this type with direct-current open arcs for street lighting, and gives some particulars of instances in which the former have been adopted. The high efficiency, economy of space, and good regulation of constant-current transformers are emphasised, and the conditions of installing and working the system are dealt with. In the discussion the use of flat carbons, 5 inches wide × ¼ inch thick, for 700 direct-current arc lamps in Philadelphia was said to be successful; one trimmer suffices for the whole of the lamps. The inefficiency of direct-current series arc light machines was pointed out, and divergent views expressed on the question of direct *versus* alternating current. A. H. A.

736. *Street Lighting.* **E. C. Jones.** (Journal of Electricity, S. F. 10. pp. 115–117, Dec., 1900. Paper read before the third annual Convention of California Municipalities, S.F., Dec. 14, 1900.)—The lighting of the streets of San Francisco by Welsbach lights is described. The lights are of 100 c.p., placed in boulevard lanterns with opal tops. They are fixed 160 feet apart along the line of the street, or, measured diagonally across the street, 180 feet. The posts have one, two, or three complete burners. A comparison is made between this method and electric lighting. The area of the mantle per c.p. being much greater than the area of the glow-lamp filament or arc-crater per c.p., a much better distribution of light is obtained. A considerable advantage is also claimed for the Welsbach in the fact that the composition of its light makes it far more penetrating through a foggy atmosphere than the arc light. The statement is made that the incandescent gas is rapidly and permanently displacing all other methods of street lighting. The present cost of street lights in San Francisco is given as follows :—

	Candle hours for 1 cent.
Ordinary gas lights	22
Arc lights	85·7
Welsbach	111

The paper concludes with a table showing the number of inhabitants of some of the large cities of the United States per 100 c.p. of street illumination. San Francisco, with 40 inhabitants per 100 c.p., comes out the best. For New York and Brooklyn the number is 86. W. W. H. G.

TELEGRAPHY AND TELEPHONY.

737. *Poulsen's Telephonograph.* **Rellstab.** (Elektrotechn. Zeitschr. 22. pp. 57–59, Jan. 17, 1901.)—In this paper there is given, in addition to a short description of the apparatus [for full description see Abstract No. 1973 (1900)], a mathematical discussion of the physical processes involved. Expressions are found for the current in the electromagnets making the record in the steel wire, the permanent magnetisation of the wire, and the current in the telephone receiver, together with the condition for obtaining correct reproduction of the tones of the human voice. C. K. F.

738. *Wireless Telegraphy.* **E. Guarini** and **F. Poncelet.** (Comptes Rendus, 131. pp. 540–541, Sept. 24, 1900.)—Electric waves generated by the sparks between the knobs of a Wimshurst Hertz machine may be divided into three kinds. The first strike the coherer directly, the second meet it after reflection, and the third have no effect. A screen will cut off the first, and the human body, even when carefully insulated from the ground, acts in this way. But a thin sheet of iron does not effect screening unless it is connected to the earth. The authors conclude that the sheet of iron becomes a fresh source of radiation acting by the induction of one of its faces on the other. Hertz waves would therefore appear to be susceptible of induction, a fact which is utilised in the Guarini repeater. M. O'G.

739. *Simple Wireless Telegraph Receiver.* **A. Trowbridge.** (Nature, 63. pp. 156–157, Dec. 13, 1900.)—The relay tongue and contact act as coherer, closing the circuit of the relay electromagnet, which produces immediate decoherence by drawing the tongue away from the contact. A telephone with condenser in series is placed as a shunt on the coherer circuit. A "dot" is heard as a single tick and a dash as a series of ticks. J. E.-M.

740. *Synchronous Impulse System of Multiplex Wire, or Wireless, Telegraphy.* **A. Bull.** (Elektrotechn. Zeitschr. 22. pp. 109–111; Discussion, p. 111, Jan. 31, 1901. Paper read before the Elektrotechn. Vereins, Dec. 18, 1900.)—This method depends on the employment of a number of different series of impulses. Each series consists of a given number of very short but perfectly similar impulses, which follow one another at definite but unequal intervals. It is by proper choice of these intervals that the various series are differentiated. Each corresponding pair of stations is so arranged that the sender can only send one type of series, and the receiver only responds to the same type. As was pointed out by Dr. Strecker in the discussion, this method is of little use, as each signal requires a number of impulses to be sent, while one impulse is sufficient for each letter if Hughes' printing telegraph be used. Hence it would be at least as rapid to send the messages consecutively to the various stations as to employ this method to send them simultaneously. J. E.-M.

REFERENCE.

741. *Telephonic Receiver for Wireless Telegraph Signals.* **Popoff** and **Ducretet.** (Comptes Rendus, 131. pp. 1296–1298, Dec. 31, 1900.)—A receiver practically identical with that used by Hughes in 1879. See Fahie's "History of Wireless Telegraphy," Appendix D. J. E.-M.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1901.

GENERAL PHYSICS.

742. *Vortex Rings.* **G. Vicentini** and **G. Pacher.** (Rivista Sci.-Industriale, 33. pp. 17–25, Feb. 15, 1901. Atti del R. Istituto Veneto di Scienze Lettere e Arti.)—This paper is a description of experiments made on the vortex rings shot from the Stiger hail-preventing cannons. The Stiger cannon is a mortar with a sheet-iron funnel, the mouth of which is partially closed by a diaphragm with circular aperture. The air in this funnel forms the vortex-ring projectile. The authors' experiments are made with miniature cannons and are adapted to the lecture-room; he examines the vortex-rings by their effects on targets of wire gauze, covered with a solution of soap and glycerine. A vortex-ring, striking such a target removes the liquid film from an annular portion, and also from the central area, leaving a narrow ring of liquid separating the two portions. The effect of funnels of different sizes and shapes is examined by means of these targets. Experiments are described with a Tait smoke-ring box, using as target a soap film on a wire ring. The nature of the vortex-ring projectiles is examined also by their action on flames, and by a Toepler manometer. G. H. B.

743. *Density of Liquid Chlorine.* **A. Lange.** (Chem. News, 83. pp. 134–136, March 22, 1901. From the Zeitschr. Angew. Chem. July, 1900.)—Results are given of measurements of the density of liquid chlorine at various temperatures and pressures, the method employed being that previously used by the author in the cases of sulphur dioxide and ammonia. The numbers obtained agree very well with those of Knietsch. The coefficient of compressibility of liquid chlorine has the values, 0·000225 at 35·4°, 0·000366 at 64·9°, and 0·000673 at 91·4°. T. H. P.

744. *Optical Methods for Studying Elasticity.* **A. Cornu.** (Archives Néerlandaises, 5. pp. 322–338, 1900.)—In studying the elasticity of some substances, *e.g.*, crystals which can only be obtained in small specimens, special methods are required. The two methods referred to are:—

I. *Using Newton's Rings.*—If the surface of the body be planed and polished, and then a convex lens placed over it, we can obtain the rings by monochromatic light. If now the body be strained by (1) a force applied perpen-

dicular to the plane surface, or by (2) a torsion, in either case the rings will change in size and shape. Then proceed to measure the rings by a micrometer, and apply Euler's theorem of the relation of the deformation of the surface to the variation of the curvatures.

II. If the surface be strained as above described, then a lens, having one of its three supports on the surface, will be rotated by a small amount; in consequence an image, which before the strain was truly sharp, now becomes *astigmatic*, and we have to observe not an image but two focal lines.

The theory of lenses will enable the movement to be found from the observed positions of the focal lines.

Details of the manipulation, and a comparison of the two methods showing that they are equally sensitive, are given. P. E. S.

745. *Relation between Brittleness and Elastic Limits for Tension and Pressure.* **C. Frémont.** (Comptes Rendus, 132. pp. 202–203, Jan. 28, 1901.)—The author arrives, from experimental data, at the important conclusion that steel is brittle (*i.e.*, breaks suddenly with small expenditure of work) or tough (*i.e.*, breaks gradually with an expenditure of work proportional to that required for rupture by tension), according as the ratio of the elastic limit for tension to the elastic limit for compression is less or greater than unity.

J. E.-M.

746. *Effect of Tension on Permanent Torsion of a Wire.* **J. R. Benton.** (Phys. Rev. 12. pp. 53–54, Jan., 1901.)—Himstedt has investigated the torsion produced in a wire hanging free with weights fastened to its lower end, when these weights are changed. The author shows that similar changes are caused in the permanent torsion of a wire by increasing its tension when it is clamped fast at top and bottom. A table of results is given. W. C. H.

747. *Poisson's Ratio Determined by Means of an Interference Apparatus.* **J. R. Benton.** (Phys. Rev. 12. pp. 36–42, Jan., 1901.)—After relating the different methods adopted by different investigators to determine Poisson's ratio, the author, desiring to measure the actual contraction in wires subjected to longitudinal stress, describes a method of, and apparatus for, measuring the contraction, naturally very small, by means of interference bands. The values of Poisson's ratio thus found for a number of wires are given in a table. The following are some of the values given :—

Steel	0·2755
Iron	0·288
Copper	0·341

W. C. H.

748. *Experimental Investigation into the Flow of Marble.* **F. D. Adams** and **J. T. Nicolson.** (Roy. Soc., Phil. Trans. 195. pp. 363–401, Jan. 5, 1901; Roy. Soc., Proc. 67. pp. 228–234, Nov. 14, 1900 (Abstract).)—Cylinders of marble, 1·5 inch high, 1 or 0·8 inch in diameter, were passed into wrought-iron tubes, built up like pieces of ordnance of strips of Low Moor iron, and fixed in the respective tube by heating the latter. Pressures up to 13,000 atmospheres were applied by vertical steel pistons from above and below. When the pressure reached 18,000 lbs. per square inch, the tubes began to bulge out, and finally burst. The experiments lasted from 10 minutes to 67 and 124 days, and were conducted in the cold and at temperatures of 300 and

400° C., in the dry and under admission of steam; the moisture made no appreciable difference. The observed permanent deformations in the marble confirm Heim's view on deformation without fracture as a factor in the mechanism of mountain formation in the deeper portions of the earth's crust. At ordinary temperature a cataclastic structure and twinning and gliding movements in the individual crystals result; at 300° C. and above, the cataclastic structure is no longer observed, the movements consisting entirely of changes in the shape of the component calcite crystals by twinning and gliding. There is thus a flow of marble identical with the flow of metals. Whether the pressure is applied rapidly or slowly, does not seem to affect the final appearance; but rapid deformation weakens the marble, reducing its resistance to crushing from 12,000 lbs. to 2,775 lbs., whilst the slowly deformed marble retains its strength. The structures of the artificially deformed marbles were found in sixteen out of forty-two specimens of natural marbles and limestones, especially selected from contorted districts; in the other cases the resemblances were doubtful or absent. H. B.

749. *Use of Bicycle Wheel in Illustrating the Principles of the Gyroscope.* **C. T. Knipp.** (Phys. Rev. 12. pp. 43–46, Jan., 1901.)—The author shows how to construct a very simple, but effective, form of gyroscope from an ordinary bicycle wheel. This works equally well as a gyroscopic pendulum, as a balanced gyroscope, and as a top. In the ordinary form of gyroscope the true oscillatory motion of the axis is not shown except for very low speeds, and even then the oscillations are quickly damped by the friction of the supports. In the bicycle wheel gyroscope the friction at the hub, on account of the ball bearings, is very much less in proportion to the masses in motion; and, as the large diameter of the wheel and consequently small angular velocity make the precessional and oscillatory motions slow, these can be followed more easily. W. C. H.

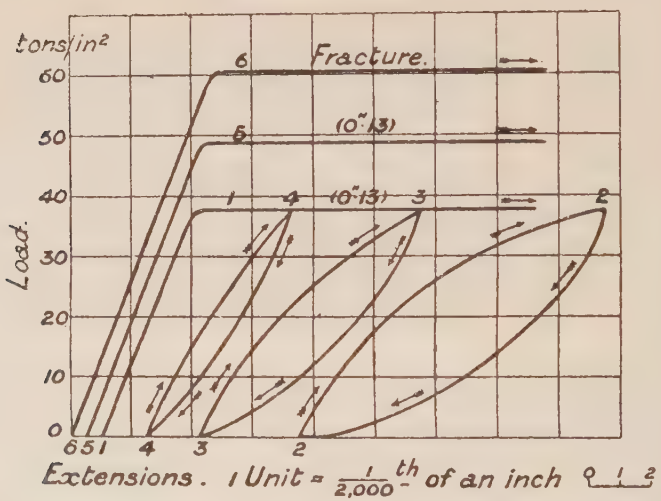
750. *Precision in Determinations of Length.* **J. R. Benoît.** (International Physical Congress at Paris, Report, 1. pp. 30–77, 1900.)—A *résumé* of the practice and progress in different countries as to the standard and measurement of length. France, England, Russia, and Germany are dealt with, and the extension of the metric system noted. The best form for standards of length is discussed and the tests they should bear are described. As to the accuracy attainable in comparing thirty standard metre bars, the probable error of a single comparison is calculated to be $\pm 0{\cdot}12\ \mu$, and the probable error of the value of any one of the bars is thus $\pm 0{\cdot}04\ \mu$. The permanence of the standards and their variations with temperature are also treated. E. H. B.

751. *Tempering of Iron Hardened by Overstrain.* **J. Muir.** (Roy. Soc., Proc. 67. pp. 461–466, Jan. 19, 1901.)—This paper describes experiments carried out on rods of iron and steel about $\frac{3}{8}$ths of an inch in diameter and 11 inches in length, the elastic condition of the material being in all cases determined by means of tension tests in which the hardness of the material was indicated by the "yield-point."

A $\frac{1}{2}$-inch rod of semi-mild steel, tested in the condition received from the makers, gave a well-defined yield-point at a stress of 38 tons per square inch, the material yielding at that stress by 0·13 inch on a 4-inch length. Curve No. 1 of the figure illustrates this. Curve No. 2 illustrates the semi-plastic state of the material produced by just passing this primary yield-point. The

specimen was then laid aside for 1¾ days and once more tested. Curve No. 3 shows the progress made during this interval of rest towards recovery of elasticity. Curve No. 4 shows the condition of the overstrained material after it had been resting for two weeks. To insure perfect recovery of elasticity, the specimen was heated to 200° C. After cooling curve No. 5 was obtained with a yield-point at 49 tons per square inch, an increase of 11 tons. The material, after this second overstrain, was once more in a semi-plastic state, and curves similar to No. 2 could have been obtained, but with the loading continued up to 49 tons per square inch. Had the loading been continued beyond this when the material was in a semi-plastic state, large yielding would have taken place and fracture would have occurred at probably a very slightly increased load. On again annealing at 200° C. curve No. 6 was obtained, showing that the specimen bore the stress of 60 tons per square inch (another increase of 11 tons), but that fracture took place at 60½ tons.

(Steel as supplied.)



Another diagram is given in the paper showing that annealing altered in an interesting manner the elastic properties of the steel, whose virgin properties were illustrated in the figure given.

This same steel, after being annealed at 750° C. before being tested, gave its primary yield-point at 29 tons per square inch, and finally fractured at 59½ tons per square inch, after its yield-point had been four times raised by a step of about 7½ tons per square inch, due to annealing at 300° C. each time.

It was found that the steel in the condition as supplied could be tempered, or partially annealed, by heating to various temperatures below 750° C., the ordinary annealing temperature, and the lower the temperature the higher the yield-point. E. C. R.

752. *Viscosities of Mixtures of Liquids and of Solutions.* **C. H. Lees.** (Phil. Mag. 1. pp. 128–147, Jan., 1901. Paper read before the Physical Society of London.)—In the endeavour to discover the law of connection of the viscosity of a mixture with the relative amounts and viscosities of its constituents, many investigations have been made of the viscosities of mixtures

and of solutions, and the results have led to several empirical formulæ being proposed, which represent with more or less accuracy the observations made. The author, after considering the necessary and sufficient conditions for the solution of any "plane" problem on the motion of viscous fluids, proceeds to discuss a few stable arrangements of the fluids for which the solutions can be readily obtained, and derives the following three formulæ :—

$$\frac{1}{\eta} = \frac{v_1}{\eta_1} + \frac{v_2}{\eta_2} + \frac{v_3}{\eta_3} + \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\eta = v_1\eta_1 + v_2\eta_2 + v_3\eta_3 + \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\log \eta = v_1 \log \eta_1 + v_2 \log \eta_2 + v_3 \log \eta_3 + \quad \ldots\ldots\ldots\ldots \quad (3)$$

where η, η_1, η_2, &c., denote respectively the viscosities of the mixture and of the separate components present therein, and v_1, v_2, &c., denote the number of c.c. of each component present in 1 c.c. of the mixture. Comparison of values calculated by these formulæ with those observed by various experimenters for a large number of mixtures and solutions, shows that no one of the three represents the viscosity of a mixture with sufficient closeness. The author therefore suggests the empirical formula,

$$\left(\frac{1}{\eta}\right)^m = v_1\left(\frac{1}{\eta_1}\right)^m + v_2\left(\frac{1}{\eta_2}\right)^m + \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where m is a constant to be determined for each mixture. This formula, with a suitable value for m gives a satisfactory representation, and when applied to express the variation of the viscosity of a single liquid with temperature, by regarding a liquid at temperature t as produced by a mixture of suitable proportions of the liquid at temperatures 0 and t_1 respectively, it leads to the formula proposed by Slotte for the variation of the viscosity of a liquid with temperature. W. C. H.

753. *Apparatus for the Circulation of Liquids at Constant Temperature.* **I. H. Derby.** (Journ. Phys. Chem. 5. pp. 17–20, Jan., 1901.)—Two devices are described for the maintenance of a stream of water between a jacket kept at a constant temperature and a bath. The water is made to pass from the bath through a tube to the jacket from which it passes back to the bath by means of another tube dipping beneath the surface of the liquid. In the first apparatus the circulation is effected by a screw propeller working at high speed in the exit tube of the bath ; the water in the latter is not well mixed in this way, so that a stirrer is necessary. In the second method, the entry tube of the bath is surrounded by another tube fitted near the top with a driving-wheel, and blown out at the bottom into a bulb, the walls of which contain two holes opposite to one another. When this outer tube is rotated, the water coming into the bath by the entry tube is thrown outwards in the form of a fine spray, and well mixed with the other water. In this case no stirrer is required, and a constant circulation is kept up. Illustrations are given of the apparatus, which give good results. T. H. P.

754. *Muscular Energy.* **A. Chauveau.** (Comptes Rendus, 132. pp. 194–201, Jan. 28, 1901.)—The subject, weighing 50 kg., was made to work by ascending or descending a Hirn wheel, carrying loads of 10 or 20 kg., at different speeds. The conditions of the experiments were not varied in other respects, and very little altogether. Each experiment lasted about ten

minutes, and the exhaled air was collected during the last six minutes ; from the analysis of this air the oxygen consumption was deduced. The ratio of work done in kgms. to the energy expenditure (the equivalent of the calories) forms the basis of the conclusions. For varying loads the energy expenditure is proportional to the load ; but work at a quick rate requires comparatively less energy than work at a slower rate. The above-mentioned ratio varied a good deal ; the average is 0·2 for ascending, and 0·389 for descending. The author considers that the energy expenditure comprises three terms :—The internal work which balances the load in the state of static contraction ; the increase or decrease in this internal work on raising or lowering the load, when the static contraction passes into a positive or negative dynamic contraction ; and the positive or negative external work corresponding to the creation or extinction of potential or actual energy. H. B.

755. *Progressive Long Waves in Shallow Water.* **R. F. Gwyther.** (Phil. Mag. 1. pp. 106–110, Jan., 1901.)—In continuation of previous papers [see Abstract No. 2143 (1900)] the author seeks the whole range of periodic long waves in water of uniform depth, limited by the condition that the uniform velocity applied throughout the fluid may make the motion steady. The different possible solutions are found to depend upon the roots of a quadratic, solutions suitable for periodic waves corresponding to intervals between the roots, and presenting themselves in the same form in terms of the elliptic function of the second kind. The resulting waves are waves of elevation, each value of the modulus corresponding to two waves travelling with different rates and accompanied by a motion of drift. In the extreme case there are obtained Scott-Russell's Solitary Wave and a comparatively slow solitary wave of elevation, accompanied by a perceptible drift. The need for this drift and the existence of long waves not accounted for by the method seem to point to the probability of a more complex motion than a uniform drift being necessary for the exhibition of the phenomena, and to throw doubts on the advantage of studying this wave by a reduction of the motion to steady motion. A condition is found for the identity of the waves with the type of Cnoidal Wave given by Korteweg and de Vries. W. E. T.

756. *Lorentz's Theory and the Principle of Reaction.* **H. Poincaré.** (Archives Néerlandaises, 5. pp. 252–278, 1900.)—The author explains in his first section how the law of equality of action and reaction is not satisfied in Lorentz's theory, if that law is to be applied to ordinary matter only. He gives an analytical expression for any component, X, of the ponderomotive force acting on the Lorentz electrons within a certain space. This expression contains two terms corresponding respectively to Maxwell's magnetic pressure and electrostatic pressure on the bounding surface of the space. It contains also a third term $\frac{d}{dt}\int d\tau\,(\beta h - \gamma g)$ in the usual notation. Now if M be the mass, V_x, V_y, V_z the component velocities, of any particle of matter within the space considered, the equality of action and reaction requires that $\Sigma MV_x = \text{constant}$. What we really obtain is, since Maxwell's pressures disappear for an infinitely distant surface, $\Sigma MV_x + \int d\tau\,(\gamma g - \beta h) = \text{constant}$. It is noted that the vector whose components are $\gamma g - \beta h$, &c., is Poynting's radiation vector.

Poincaré then supposes the electromagnetic energy of which Poynting's

vector denotes the flow, to be an imaginary fluid possessing inertia, of density K_0J, where $\frac{1}{\sqrt{K_0}}$ is the velocity of light, so that K_0JU_x represents the x component of Poynting's vector. He makes a special hypothesis to get over the difficulty that the imaginary fluid is not indestructible, but its quantity is subject to increase or diminution by interchange with other forms of energy.

Assuming the imaginary fluid to possess inertia, we should expect that the apparatus *e.g.*, a Hertz oscillator, which produces electromagnetic energy, and sends it on its way through space, should recoil like a fired cannon, though, as shown, such recoil would not be measurable by our methods. The new term introduced, namely, $\frac{d}{dt}\int d\tau\,(\beta h - \gamma g)$, disappears as stationary motion is established. The recoil, therefore, depends ultimately only on Maxwell's pressures. And since all theories involve Maxwell's pressures, they all involve the same recoil.

In his second section Poincaré considers the question why Lorentz's theory, which does not obey the law of action and reaction, and Hertz's theory, which does obey it, lead to the same recoil. To answer this he discusses the case of a material dielectric, and the passage of a wave through it on Lorentz's principles. He explains that Lorentz's theory stands in the same relation to that of Hertz, as Mossotti's theory to that of Maxwell. We pass from the one to the other by assuming the polarised particles of the original one to become infinitely small in the derived theory. If $\frac{1}{\sqrt{K_0}}$ denote the velocity of light in Lorentz's original theory, we must in a modified theory use $\frac{1}{n_0\sqrt{K_0}}$, n_0 being the index of refraction of so-called vacuum in relation to an ideal unpolarisable medium. The author then shows that when the apparatus projects energy into space, part of the recoil is taken up by the dielectric, and part by the apparatus, the proportion of the whole taken by the dielectric being $\frac{n^2-1}{n^2+1}$ where n is the index of refraction of the dielectric. In the modified theory we must use $\frac{n^2n_0^2-1}{n^2n_0^2+1}$ instead of $\frac{n^2-1}{n^2+1}$. For Hertz's theory n_0 is infinite, and therefore *the whole recoil* is taken by the dielectric. This is the reason why Hertz's theory obeys the law of action and reaction.

In his third section the author discusses the principle of action and reaction, and our reason for assuming it as axiomatic, from a general point of view. It is intimately connected with the theory of relative motion. To show this he considers the case of two observers at a distance x from each other, who set their watches by signalling through the intervening distance without being aware that they have a common velocity v of translation through space. If t' be the time so observed, t the real time, and V the velocity of light, we have, he shows, $t' = t - \frac{vx}{V^2}$. The apparent energy is propagated in the relative motion according to the same laws as the real energy in the real motion. But the apparent energy is not precisely equal to the real energy.

In the relative motion the bodies which emit energy are subject to a certain *complementary force* which is obtained as follows:—

Suppose, for instance, a Hertz oscillator placed at the focus of a parabolic mirror, whose axis is taken for that of x. The system is supposed to have a

small velocity v' of translation in that direction. The apparatus experiences a recoil with velocity v' in the opposite direction, and v' is supposed greater than v, so that v^2 is neglected, but not vv'. The force of the recoil is equivalent to the increase of momentum of the imaginary Poynting fluid, namely, $K_0JV = J/V$. The energy of the recoil is therefore $-\frac{Jv'}{V}$. If D be the energy spent by the oscillator, the equation of energy of the real motion is—

$$J - D - v'J/V = 0.$$

For the apparent motion, taking into account the translation velocity v, we substitute $J\left(1-\frac{v}{V}\right)$ for J, and $v'-v$ for v'. The resulting apparent equation of energy is $J\left(1-\frac{v}{V}\right)-D+J\left(\frac{v'}{V}+\frac{v}{V}+\frac{vv'}{V^2}\right)-\frac{Jvv'}{V^2}=0$. The last term is necessary to make the apparent equation of energy agree with the real equation. It implies a force on the apparatus $-\frac{Jv}{V^2}$, which does work $-\frac{Jvv'}{V^2}$ on the apparatus moving with the recoil velocity v'. This force the author calls *the complementary force.*

This is the explanation of the fact that in Lorentz's theory the principle of action and reaction cannot apply to matter alone, and the same is true of the principle of relative motion. S. H. B.

757. *Surface Tension.* **H. Halshof.** (Ann. d. Physik, 4. 1. pp. 165–186, Jan., 1901.)—The object of this paper is to show that the assumptions on which is based the equation of condition for a substance whose density changes continuously in a capillary layer lead to the conclusion that surface tension exists. The assumption of continuity of density requires that all densities between that of the liquid and that of its saturated vapour should be represented. It does not, however, follow that all states represented by an isotherm must be found in the capillary layer. For the states represented by different points of the isotherm presuppose a certain homogeneity of the substance. Those functions only which depend on the molecular velocity and the density will have the same value in the transition layer as in a homogeneous distribution. This is the case with the entropy and the thermal pressure δ. Supposing a thin column of fluid of base ab perpendicular to the fluid surface and in the external space, and supposing no forces to act except the molecular attraction, the molecular pressure is defined to be the force with which the substance on one side of the plane on which ab lies attracts the column of fluid in a direction perpendicular to the surface. If the distribution is not homogeneous the molecular force will have different values in different directions. The writer assumes that the density has at every instant the same value at every point of any horizontal layer, but is a function of the vertical distance from a given horizontal plane, and on this hypothesis he calculates the molecular pressure, first in the vertical and then in a horizontal direction. The vertical component is shown to have a different value from the components in the surface. And this fact it is, according to the present paper, which gives rise to surface tension. The surface tends to contract itself with a force depending on the difference between the components of the molecular attraction. The relations of the phenomenon to changes of temperature and density are investigated.

S. H. B.

758. *Rigidity of Liquids.* **T. Schwedoff.** (International Physical Congress at Paris, Report, 1. pp. 478–486, 1900.)—The author points out that the distinction between solids and liquids is not in all respects abrupt, but that solids show some of the properties commonly ascribed to liquids, and *vice versâ*. He describes an experiment of Maxwell's, afterwards repeated by Kundt and Metz, in which a liquid was contained in the space between two coaxial cylindrical vessels, the inner vessel being set in rotation, and it was found that the liquid, affected by the rotation of the inner cylinder, had the property of polarising light. M. Schwedoff then describes an experiment of his own, in which a cylindrical glass vessel filled with granules was suspended by a steel wire in the interior of another vessel, the space between the vessels containing the liquid to be observed. The wire being then thrown into a state of torsion, the suspended vessel acquires rotation and communicates it to the liquid. The theory of this experiment is represented by the formula—

$$E = a\frac{\delta}{w}$$

Where δ and w are the angles of torsion of the wire and liquid respectively at the instant of equilibrium, a is a constant, and E the modulus of rigidity required.

The writer also discusses the relation between deformation in liquids and internal friction, first raised by Maxwell, and arrives at the following results :—(1) The viscosity of a liquid depends on its modulus of rigidity, on the limit of its spring, on the speed of relaxation, and on the speed of deformation. (2) The viscosity of a liquid is not constant, but may vary with the speed of deformation. (3) The change in viscosity is more sensible as the limit of elasticity increases. (4) When the rigidity cannot be measured directly, the liquid may nevertheless be very viscous, if the speed of relaxation be small. (5) On the other hand, a liquid may present great fluidity and yet have a measurable modulus of rigidity, that is if the speed of relaxation be very great. S. H. B.

759. *Action at a Distance in Hydrodynamics.* **V. Bjerknes.** (International Physical Congress at Paris, Report, 1. pp. 251–276,1900.)—The author supposes an infinite incompressible fluid. If in that fluid there be a very small sphere which, without changing the position of its centre, increases or diminishes its radius, it causes a radial movement in the fluid, the velocity of which varies inversely as the square of the distance from the sphere, and may be derived from the potential $\phi = -\frac{E'}{4\pi r}$, where E′ is the velocity of expansion of the sphere, r the distance from its centre. If there be a number of such spheres in the fluid, we have, by a simple enumeration, $\phi = -\Sigma\frac{E'}{4\pi r}$. If the oscillation is for each sphere the same periodic function of the time, the spheres are said to have *synchronic pulsations*, and in this case the field is, as regards its mean state, constant.

From a pulsating sphere to a sphere of constant volume moving with finite velocity a', b', c', in direction s, the transition is effected by known methods, and it is found that in this case $\phi = -S'\frac{d}{ds}\frac{1}{4\pi r}$, where S′ is the vector whose components are $F' = \frac{3}{2}a'E$, $G' = \frac{3}{2}b'E$, $H' = \frac{3}{2}c'E$. On these data the writer discusses the mathematics of a sphere moving in the fluid

with velocity a', b', c', under the influence of a stream α', β', γ', caused by the pulsation or motion of other spheres. He finds that the force X, acting at any instant on the sphere, consists of two parts, namely $X = X_i + X_e$. Here $X_i = -g\frac{d}{dt}\left\{E\left(\frac{1}{2}a' - \frac{3}{2}\alpha\right)\right\}$, with corresponding components Y_i, Z_i, and g is the density of the incompressible fluid. This force is called the *force of induction*. The other part of X, or X_e, is given by—

$$X_e = -g\alpha' E' - g\left(\frac{da'}{dx}F' + \frac{da'}{dy}g' + \frac{da'}{dz}H'\right),$$

with corresponding equations for Y_e and Z_e. This is called the *energy force*. The effects of the force of induction are found to correspond with well-known properties of the electric and magnetic forces in an electric field.

The energy force is again divided into two parts, the permanent and the temporary force, of which the former is independent of the stream, the latter depends upon it. The permanent force has its origin in pulsations or oscillations of a sphere independent of the stream, the latter on oscillations caused by the stream, and depends, therefore, ultimately on the pulsations or oscillations of other spheres. It is found that the permanent force diminishes according to the second, third, and fourth inverse powers of r, whereas the temporary force depends on the fifth and higher powers. The general conclusions at which the author arrives are as follows: Imagine a world consisting of spheres immersed in an incompressible fluid, and pulsating or oscillating, and that groups of such spheres form substances. The inhabitants of such a world, unaware of the existence of the fluid, would conclude from observations of the spheres that they were acted upon by forces at a distance, according to the Newtonian law, and subject to the conservation of energy. But, in fact, the only actions are contact actions due to the (to these inhabitants) unknown fluid. The writer concludes with a discussion of the analogy between his own hydrodynamic system and the electric or magnetic system, notably the theory of Hertz. He claims that his theory, as shown in this paper is, in some points, an advance on Hertz's theory, because he gives the mechanism of the medium whereby contact forces give rise to (apparently) forces acting at a distance, whereas Hertz was unable, from the nature of his work, to specify the mechanism. He refers also to O. Heavisides' system of "rational" units, according to which we take for the unit of force between two attracting spheres m and m', not $\frac{mm'}{r^2}$, but $\frac{mm'}{4\pi r^2}$. And this system he considers must sooner or later be adopted.

S. H. B.

760. *General Principles for the Dynamics of Ether.* **J. Farkas.** (Archives Néerlandaises, 5. pp. 56–75, 1900.)—The writer considers that the scientific treatment of dynamics is as yet deficient in generality. An extension is required both for ordinary mechanics and for ether. He proposes to use the principle of virtual displacements in the form given by Fourier and Gauss, that is, the principle of inequations, which has advantages over that of equations. Generally the principle of virtual displacements, whether in the form of equations or inequations, is applicable only when the surrounding medium has no resistance and there is no friction. In his first chapter the author extends the principle so as to include the case where these exist. In his second chapter he generalises the analytical expression for constraint. This

is generally assumed to be expressible by homogeneous linear equations or inequations, among the displacements. But there are cases, he maintains, in which such relations are insufficient. In the above first and second chapters only discrete masses are considered. In the third the treatment is extended to matter continuous in space. This also includes a generalisation of the equation of continuity. In the fourth chapter the hypothesis is dealt with that in an independent system of masses, for certain positions of the axes of co-ordinates, no free forces appear. And this hypothesis is applied to the relations between the ether and matter in any space regarded as parts of the same dynamical system. In the case of certain bodies it is necessary to assume that different portions of ether in the same space are subject to different constraints, and that these may be converted one into another. Experience teaches us that surface friction between ether and matter can be only very slight in all motions which we can observe. But this is not inconsistent, says the author, with the hypothesis that in the interior there may be considerable friction. Nor is this hypothesis inconsistent with Lorentz's assumption that ether has nothing to do with—*i.e.*, takes no part in—the visible motions of bodies. S. H. B.

761. *Capillary Phenomena.* **G. van der Mensbrugghe.** (International Physical Congress at Paris, Report, 1. pp. 487–511, 1900.)—The writer refers to experimental proofs of the great elasticity of liquids, firstly under compression, secondly under traction. From these proofs he draws the conclusion that liquids cannot be regarded practically as incompressible, and that a liquid cannot have a uniform density at all points in its substance; for that if it had, equilibrium would be impossible. The writer does not, however, give a definition of density as a function of the position of the point considered varying from one point to another within the same liquid.

From these considerations he draws the following conclusions:—Firstly, that superficial tangential tensions must exist in the outer layer of the liquid; secondly, that normal tension must exist, giving rise to evaporation: and these conclusions are, he says, confirmed by the experience of engineers.

Next he discusses the relations that prevail between these functions, at the surface of contact (1) of a solid and a liquid, (2) of two liquids, and the theory of the spreading of one liquid over the surface of another. The law found is, that in order that one liquid may spread over the surface of another, it is sufficient and necessary that the mutual action should be greater than the tension of the two surfaces. Finally is discussed the equilibrium of a thin column of liquid within another liquid. S. H. B.

762. *Laplace's Capillarity Constant.* **G. Bakker.** (Journ. de Physique, 10. pp. 135–139, Feb., 1901.)—If $f(r)$ denote the force acting between two molecules at distance r, and if—

$$\phi(r) = \int_r^\infty f(r)dr, \quad \psi(r) = -\int_r^\infty r^2(\phi r)dr,$$

the potential energy for volume v is—

$$W = 2\pi\psi\rho^2 v D,$$

ρ being the density, and D the diameter of a molecule. Referring to a

former paper (Journ. Phys. 3 serie t VII. p. 511, 1898) the writer finds for the virial of the molecular forces, $\mathfrak{A} = \frac{3}{2} v\frac{dw}{dv}$, whence $2\mathfrak{A} + 3W = 0$, or if A is the work done in removing all the molecules out of one another's field, $3A - 2\mathfrak{A} = 0$. In the present paper he proves that the expression $(3A - 2\mathfrak{A})$, which is zero at any point in the interior of the liquid, is in fact the surface tension in the case of the capillary layer. He adopts the form of force for distance r arrived at in the paper referred to in Abstract No. 2139 (1900), namely $-f\frac{\epsilon^{-qr}}{r}$. And then, following van der Waals, he gives for the potential at a point in the capillary layer—

$$V = -2a\rho - \frac{c_2}{1\,2}\frac{d^2\rho}{dh^2} - \frac{c_4}{1\,2\,3\,4}\frac{d^4\rho}{dh^4} \text{ \&c.,}$$

in which—

$$c_n = \int_C^\infty u_n \psi(u) du,$$

and—

$$\psi(u) = 2\pi\int_n^\infty u\phi(u)du,$$

$\phi(u)$ being the force. Again, in the paper of July, 1900 [Abstract No. 2139 (1900)], he had obtained for the surface tension H, the expression—

$$H = \frac{1}{4\pi f}\int_1^2 \left(\frac{dV}{dh}\right)^2 dh,$$

V being van der Waals' potential above mentioned, dh an element of the normal to the two surfaces of the layer, and the indices 2 and 1 referring respectively to the saturated vapour and to the liquid. And the last expression is proved equal to $3A - 2\mathfrak{A}$. [See also Abstracts Nos. 2138 and 2139 (1900) and 509 (1901).] S. H. B.

763. *Numerical Relation between the Two Elasticity Constants of Isotropic Substances according to the Molecular Theory.* **W. Voigt.** (Ann. d. Physik, 4. 1. pp. 187–196, Jan., 1901.)—The old molecular theory gave results for isotropic media which could not be reconciled with experience. Voigt's investigations pointed to the assumption that intermolecular forces depend only on distance as the source of error, and the difficulty appeared to vanish in the case of crystalline bodies on assuming the force to depend for its direction on the symmetry relations of the crystal. The same method, applied to isotropic media, led only to the erroneous theory, so long as such media are regarded as molecularly isotropic; *i.e.*, so long as neighbouring molecules are orientated with respect to each other in all directions indifferently. For on that assumption, we have the equation—

$$-X_x = CX_x + C_1Y_y + C_1Z_z,$$
$$-Y_z = \tfrac{1}{2}(C - C_1)\,Y_z,$$

with the relation $C = C_1$, which is inconsistent with experience. The difficulty disappears if we assume the isotropic bodies to be made up of fragments of crystalline substance in all possible orientations—a state which Voigt defines as *quasi isotropy*. This solution being inapplicable to liquids, the object of the present paper is to show how the difficulty can be removed.

Voigt obtains the following formulæ [(7) in his notation] :—

$$u' = x_x x' + \tfrac{1}{2} x_y y' + \tfrac{1}{2} x_z z',$$
$$v' = \tfrac{1}{2} y_x x' + y_y y' + \tfrac{1}{2} y_z z',$$
$$w' = \tfrac{1}{2} z_x x' + \tfrac{1}{2} z_y y' + z_z z',$$

in which x', y', z' are the co-ordinates, u', v', w' the displacements of a molecule, relative to a type molecule. These are the fundamental equations of the "Nahewirkung" theory of elasticity. But these, he says, cannot be applied to the molecular theory except on the following assumption, namely, "that within the molecular sphere of action, molecules behave, when deformation takes place, like particles of a continuous medium capable as well of translations and rotations in mass as of uniform dilatation in three mutually perpendicular directions." Substances for which this assumption may be at once admitted are to be regarded as ideal liquids. On the other hand the formulæ (7) are to be regarded as characteristic of elastic solids. A third class of bodies to which (7) are inapplicable are to be regarded as possessing a certain degree of fluidity.

Voigt finally obtains a set of formulæ from which C/C_1, the ratio of the two constants, can be calculated, and may have any value between 1 and 3, according to the degree of rigidity. The result is compared with Thomson's "modulus of rigidity." S. H. B.

764. *Artificial Solar Eclipse.* **R. W. Wood.** (Science, 13. pp. 65–67, Jan. 11, 1901.)—The article gives particulars of the construction of an apparatus which may be useful for representing a total solar eclipse. An electric glow-lamp is suspended in a tank containing a slightly milky fluid (water and mastic varnish) and having an opaque disc in front to represent the dark moon. Bands of opaque paper pasted on the lamp produce the appearance of coronal streamers radiating from the moon's limb. The article is illustrated by a photograph of the appearance produced. C. P. B.

765. *Electromagnetic Foundation of Mechanics.* **W. Wien.** (Archives Néerlandaises, 5. pp. 96–107, 1900.)—While acknowledging the great services rendered by various workers on the relation between mechanics and electromagnetic phenomena, the author feels that the present state of theory leaves much to be desired. The view is then put forward that the most promising direction for theoretical work lies in the reversal of the usual methods, and the seeking of a possible electromagnetic theory of mechanics instead of a mechanical theory of electromagnetism.

The conception of the electric and magnetic polarisations of free ether, as expressed by Maxwell's differential equations, are then taken as fundamental, and written as follows :—

$$A\frac{\partial X}{\partial t} = \frac{\partial M}{\partial z} - \frac{\partial N}{\partial y}, \quad A\frac{\partial L}{\partial t} = \frac{\partial Z}{\partial y} - \frac{\partial Y}{\partial z}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and the two corresponding groups of equations, where X, Y, Z, are the components of the electric polarisation, L, M, N, those of the magnetic polarisation, A the reciprocal of the velocity of light, and x, y, and z the rectangular co-ordinates.

From these, by space differentiation, addition and time-integration, are derived—

$$\frac{\partial X}{\partial x} + \frac{\partial Y}{\partial y} + \frac{\partial Z}{\partial z} = -4\pi\sigma, \quad \frac{\partial L}{\partial x} + \frac{\partial M}{\partial y} + \frac{\partial N}{\partial z} = -4\pi m, \ldots\ldots\ldots\ldots(2)$$

σ and m being respectively the electric and magnetic quantities.

On multiplying the first column of equations (1) by X, Y, and Z, and the second by L, M, and N, adding the whole together, and integrating throughout a closed space whose surface element is dS and its normal n, the following is obtained :—

$$\frac{1}{8\pi}\frac{d}{dt}\iiint dx\,dy\,dz\,(X^2+Y^2+Z^2+L^2+M^2+N^2)$$

$$=\int dS\left\{(YN-ZM)\cos(nx)+(ZL-XN)\cos(ny)+(XM-YL)\cos(nz)\right\}\quad\ldots(3)$$

If on the surface either X, Y, and Z, or L, M, and N vanish, we have—

$$\frac{1}{8\pi}\iiint dx\,dy\,dz\,(X^2+Y^2+Z^2+L^2+M^2+N^2)=\text{constant}\quad\ldots\ldots(4)$$

The left side of (4), which is constant, when taken over a sufficiently large space is called the electromagnetic energy.

The assumption is now made that mechanical phenomena are of electromagnetic nature and may therefore be developed upon the foregoing basis.

It is further assumed that what is termed matter is made up of the positive and negative electric quantities or elements which we regard as the convergence points of the lines of force. The ether itself is regarded as at rest. Changes of position are ascribed only to the electric quantities. All forces are considered to be of the electromagnetic type and are traced to stresses in the ether.

At low velocities of the moving quantities electrostatic forces would act between them. Whether the molecular forces are explainable in this hypothesis must be left for the present. It is, however, clear that by different groupings of positive and negative quantities at different distances very complex effects could be obtained. By these assumptions it is believed possible to diminish the difficulty which has hitherto been felt respecting Michelson's interference experiment and the theory of the ether at rest. For H. A. Lorentz has shown that the length of a body in the direction of the earth's motion with velocity v is shortened in the ratio $\sqrt{1-A^2v^2}$, if the molecular forces can be replaced by electrostatic forces. Hence Michelson's result is explained, if we can apply this to the molecular motions. The theories of gravitation, inertia, apparent increase of mass in rapidly moving bodies (as in kathode rays), and the laws of motion are then dealt with on this electromagnetic basis. E. H. B.

REFERENCES.

766. *Sources of Error in the Cavendish Gravitational Balance.* **M. Brillouin.** (Comptes Rendus, 131. pp. 1293–1296, Dec. 31, 1900.)—The author gives values for the corrections which must be made in determining the constant of gravitation, by Cavendish's method, on account of the combined action of the ellipsoidal form of the earth and temperature-change of rigidity of the wire ; and discusses the corrections necessary to eliminate the effects of the gravitational potential of the building in which the experiment is made. J. E.-M.

767. *Atmospheric Electricity.* **A. G. M'Adie.** (Journal of Electricity, S.F. 10. pp. 47–48 ; Discussion, pp. 48–49, 1900. Paper read before the Electrical Transmission Convention.)—Notes on lightning. Mention is made of experiments in which three cameras, fixed in different parts of Washington, were directed upon the Washington Monument with the object of constructing a rough model of a flash. No results have been obtained so far. [See also Abstract No. 1836 (1900).] H. B.

768. *Experimental and Mathematical Physics.* **H. Poincaré.** (International Physical Congress at Paris, Report, 1. pp. 1–29, 1900.)—An able discourse on the relations between experimental and mathematical physics. Experiment is the unique source of facts, but facts alone do not constitute science any more than a heap of stones are themselves a building. Essential as the facts are, the generalisation that unites them is equally so, if we are to have a science worthy the name. The unity of nature, the *rôle* of hypothesis and the origin of mathematical physics are then dealt with, the significance of physical theories insisted upon and the advance of physics traced to the end of the nineteenth century. E. H. B.

769. *Properties of Solids under Pressure.* **W. Spring.** (International Physical Congress at Paris, Report, 1. pp. 402–431, 1900.)—This paper is a summary of the results hitherto obtained by the author and other observers in the examination of the behaviour of solid substances under high pressures. The properties dealt with include plasticity, elasticity, allotropic transformations, agglutination, diffusion, and chemical reactions in solids. References are given to the sources of information consulted. N. L.

770. *Transient Deformations of Solids.* **C. E. Guillaume.** (International Physical Congress at Paris, Report, 1. pp. 432–448, 1900.)—Transient deformations are produced, and disappear, slowly, and occupy a position intermediate between perfectly elastic deformations and permanent changes of form. Such are the displacement of the zero of thermometers, thermal and electric changes in certain alloys, phosphorescence, &c. The author gives a *résumé* of the phenomena hitherto observed and seeks their explanation in the theory that all substances exhibiting transient deformations are in a state of chemical equilibrium which varies with external conditions, and to which they slowly attain when these conditions are modified. N. L.

771. *Spectroscopic Results at Solar Eclipse, May 28, 1900.* **E. B. Frost.** (Astrophys. Journ. 12. pp. 307–351, 1900.)—Full tables are given of the lines reduced from the photographs of the spectrum of the chromosphere obtained during the eclipse with prismatic cameras, &c., and subsidiary discussions of the probable origins of many of the lines. C. P. B.

772. *Detection of Solar Corona in Daylight.* **G. E. Hale.** (Astrophys. Journ. 12. pp. 372–375, 1900.)—This paper gives a *résumé* of the results obtained during the last seven years in connection with the problem of detecting the existence of the solar corona, during full sunlight, with a bolometer. The whole of the thermal radiation is employed, in contrast to the work of Deslandres, who uses the infra-red rays only. Although much of the work has given negative results, the work done in 1900 gave promise and is being continued with the exceedingly sensitive Nichols radiometer at the Yerkes Observatory. C. P. B.

773. *Gyrostatic Pendulum Experiments.* **V. Dvořák.** (Phys. Zeitschr. 2. p. 224, Jan. 12, 1901.)—A few experiments with a gyrostatic pendulum are here described, one illustrates nutation, another the so-called polygonal pendulum, and the others conical pendulums with greatly increased and greatly diminished periods. J. B. H.

774. *Influence of Bending and Straightening on the Elasticity of Iron.* **M. Rudeloff.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 46–53, Jan. 12, 1901. Communicated by the Kgl. mech.-techn. Versuchsanstalt.)—In testing the strength of iron pipes a different result is obtained if the pipe is tested as a whole from that calculated from the results of tests made on a test specimen cut from the pipe. This may be due to the straightening to which the best specimen is previously subjected. The author has accordingly here investigated the influence of bending, straightening, and annealing on the elastic properties of iron. The results are given in tables and curves in the paper. J. B. H.

LIGHT.

775. *Electrodynamic Theory of Helmholtz and the Electromagnetic Theory of Light.* **P. Duhem.** (Archives Néerlandaises, 5. pp. 227–236, 1900.)—The writer refers to a former communication to the Faculty of Sciences at Bordeaux, 1899–1900, in which he had shown that Helmholtz' system leads to a complete electromagnetic theory of light. He here gives a brief account of the results obtained, with a view to a detailed exposition in future.

In the present paper he gives Helmholtz's fundamental equations. In a non-magnetisable medium, if v denotes the ratio between the coefficients of electrostatic and electromagnetic action, we have in Helmholtz's notation—

$$v^2 = \frac{\varepsilon}{a^2(1 + 4\pi\varepsilon F)}$$

If the medium be capable only of feeble magnetisation, the above expression becomes—

$$v^2 = \frac{\varepsilon}{a^2(1 + 4\pi\varepsilon F)(1 + 4\pi f)}$$

In a non-conducting dielectric, the velocity of propagation of a wave of longitudinal displacement is—

$$L = \frac{1}{a}\sqrt{\frac{1 + 4\pi\varepsilon F}{4\pi K F}}.$$

That of a wave of transverse displacement is—

$$T = \frac{1}{a\sqrt{2\pi F(1 + 4\pi f)}}.$$

Maxwell's known laws are compared with these results of Helmholtz.

Helmholtz leaves K undetermined, remarking only that if while a^2KF remains finite, εF becomes very great, longitudinal displacements cannot exist—a conclusion at which Maxwell also arrives. But Duhem proposes in the present paper to modify this result, by so determining K as to make ε/a^2K finite.

For this purpose he investigates the phenomena of reflection and refraction at the interface of two media, when the incident wave is one (1) of longitudinal displacement, (2) of transverse displacement. The results obtained in the latter case agree with those of Fresnel.

The conclusions drawn are—(1) That it is possible, following Helmholtz's method, to give a complete theory of reflexion and refraction at an interface. (2) That by aid of the hypotheses of Faraday and Mossotti, the results may be shown to agree with the known laws of reflexion and refraction, although waves of longitudinal displacement are not excluded. S. H. B.

776. *Velocity of Light.* **A. Cornu.** (International Physical Congress at Paris, Report, 2. pp. 225–246, 1900.)—In this report the author describes briefly the toothed-wheel method by which he obtained the velocity 300·400 km. per sec., the revolving mirror method as modified by Michelson and Newcomb, and the method of Young and Forbes. He indicates as a fatal weakness in the last the use of a metallic mirror with a hole in the

centre, in place of the usual plate of unsilvered glass. Newcomb's method is spoken of as substantially identical with Michelson's, but with improvements in details [no mention being made of the changed position of the lens], and Newcomb's result 299·860 is adopted as representing the revolving mirror method. The half sum 300·130 of these two results is the final result adopted as most probable. [Since the communication of this report, Perrotin has obtained the value 299·900 by the toothed-wheel method. See Abstract No. 42 (1901).] A. E.

777. *Double Refraction in Transversely Vibrating Glass Plates.* **W. König.** (Ann. d. Physik, 4. 1. pp. 1–40, Jan., 1901.)—When transverse vibrations take place in an oblong glass plate with free ends and two or more nodal lines, there exists, answering to the periodic bending of the plate, a periodic double refraction of the same sort as that produced by the static bending of the plate. This paper contains an experimental and theoretical investigation of this double refraction.

In transversely vibrating glass plates two kinds of double refraction are observed. In the loops only the one kind is present, in the nodes only the other kind; at the intermediate positions both exist at the same time.

The double refraction which appears at the loops is caused by the curvature of the plate, and is of the same sort as that which is produced in known ways by static bending. Its axes lie in the direction of the length of the plate and at right angles to it; its intensity increases from the neutral middle line towards the edges, proportionally to the distance from the middle line, and the magnitude of the specific double refraction of the glass, as determined by these observations, is just as large as that found from observations on statically bent plates.

The double refraction existing in the nodes is originated by the shearing forces called into action in the plate by its bending. Its axes are at an angle of 45° to the length of the plate; its magnitude is small; it appears, answering to theory, to have its greatest value in the middle of the plate and to fall off towards the edges. Its relation to the amplitude of vibration of the plate agrees almost exactly with that value which results from theoretical calculation, if the expression given by Saint-Venant for the shearing forces in static bending is transferred to the bending of the vibrating plate. J. J. S.

778. *Double Refraction due to Stress.* **Rayleigh.** (Phil. Mag. 1. pp. 169–178, Feb., 1901.)—The stresses in an elastic solid due to unequal heating are here first of all theoretically considered, and then, by giving definite form to the body and definite temperature conditions, the state of stress as given by the equations is tested by experiment. If the body be of glass, or other similar transparent substance, the state of stress may be determined by examining the body between crossed Nicols and noting the double refraction. This is done for two cases. (1) A plate of glass 8 cm. square and 1 cm. thick has the opposite edges polished. When placed in the polariscope it shows but little revival of light so long as the temperature is uniform. The contact of the hands with the two faces suffices to cause an almost instantaneous illumination, rising to a maximum at the middle of the thickness after a few seconds. Dark bands situated about halfway between the middle and the faces are a conspicuous feature. After about 30 or 40 seconds the light fades greatly—a result more rapidly attained if the hands be removed after 10 or 20 seconds' contact. The varying conditions of stress indicated by these bands is in qualitative agreement with that deduced theoretically. (2) A short

length of glass rod in its natural imperfectly annealed condition is used to illustrate symmetrical stress. The nature of the stress present in the so-called *toughened* glass is also investigated experimentally.

The paper is of a mathematical nature, but these few particular examples illustrate the general problems of the stresses in slabs and rods with which it deals. J. B. H.

779. *Refraction within Telescope Tube.* **J. Renton.** (Nature, 63. pp. 334–335, Jan. 31, 1901.)—There has been much discussion over an unexplained discordance which is found in comparing the zenith-distance of a star obtained by direct observation with that obtained by observing it reflected in a pool of mercury. The author attributes this discordance to difference of temperature in the *stagnant air within the telescope tube.* The upper side of the tube is cooled by radiation, while the lower is protected, causing a transverse gradient of temperature in the air inside. The rays passing through the tube will thus be bent upwards, so that the Z.D. observed directly will be too great, and the Z.D. by reflection too small. The error is of peculiar importance from the fact that it affects to a relatively large amount the zenith-distances of polar stars, and hence the deduced results for latitude. The time of exposure in observing a north star is generally greater than for a south star, since the observation in right-ascension, which is made at the same time, takes longer in the case of a slow moving polar star. Another discordance found in the Greenwich observations may be similarly explained. When the north and south collimators are aligned by looking through the holes in the telescope-cube, the collimation error differs systematically from that obtained by aligning with the telescope raised out of the way. At the hour, 8 a.m., when these observations are made, one side of the instrument is generally warmer than the other. The conclusion is drawn that means should be used for circulating the air in the tube. A. E.

780. *Refraction Curves for Prisms.* **A. de Gramont.** (Journ. de Physique, 10. pp. 97-116, Feb., 1901.)—Curves for flint-glass prisms are given, and discussed, showing variation of—(1) index with wave-length, (2) deviation with incidence, (3) dispersion with incidence. The calculated numbers were checked by actual spectroscopic observation of certain bright lines. To get the angles of incidence, the position of the prism for normal incidence was first obtained thus :—A pocket lens, and a piece of unsilvered glass placed at 45°, were held before the slit, and the observer, looking through these down the collimator, brought the slit into coincidence with its image in the face of the prism. The second curve, in which $x =$ deviation, $y =$ angle of incidence, resembles a parabola placed obliquely. At the point corresponding to minimum deviation the ordinate becomes a tangent. The different curves corresponding to different wave-lengths all have their upper ends on a line ($y = 90$) parallel to the axis of x, and their lower ends on another line inclined at 45° ($y = x - 90 + A$). As A, the angle of the prism, increases, this line shifts to the left, and the arcs are shortened. Further, the points corresponding to minimum deviation of all the curves, lie on a third line $2y = x + A$, which bisects all chords parallel to the axis of y, and passes through the intersection of the first two lines. When $\mu \sin \frac{A}{2} = 1$ the curve shrinks to a point. A. E.

781. *Refractive Indices of Calcium Chloride Solutions.* **G. J. W. Bremer.** (Archives Néerlandaises, 5. pp. 202–213, 1900.)—According to M. B. Walter (Wied. Ann. 38. p. 107) the refractive index of a solution increases proportionally to its concentration. If n is the index of the saline solution, n_0 that of water for the same wave-length, then $(n - n_0)/p$ is constant, when p is the weight of anhydrous salt in 100 gm. of the solution. The author has extended this investigation to other wave-lengths than those considered by Walter, and has in especial determined the refractive power of solutions of different concentration for different wave-lengths. The refractive power is calculated by H. A. Lorentz's formula $(n^2 - 1)/(n^2 + 2)d$, when n is the refractive index and d the density. His conclusions are as follows :—(1) The refractive power of a solution of calcium chloride, for the same rays, does not depend upon its concentration, and it differs little from that of water. (2) The differences between the indices of refraction of a given solution of calcium chloride and those of water for the same rays are approximately the same for waves of different lengths. (3) For solutions of calcium chloride these differences are proportional to the amount of anhydrous salt dissolved in 100 gms. of the solution. D. E. J.

782. *Astigmatic Lenses.* **R. J. Sowter.** (Phil. Mag. 1. pp. 239–246, Feb., 1901. Paper read before the Physical Society of London.)—If we take a section of a lens surface perpendicular to the axis of the lens, we get a curve which we may call a natural aperture. If we take similar sections of similar lenses, each one at the same distance along the axis of the lens from the point where the axis meets the surface, then the powers of the different lenses are inversely proportional to the squares of the radii of these similar sections. In any one lens also where the section is not a circle, the power in any direction is inversely proportional to the square of the radius vector in that direction. The author applies this to astigmatic lenses in general and to the combination of two cylindrical lenses crossed at right angles and also crossed obliquely. J. B. H.

783. *Fading of Photographic Plates.* **W. J. S. Lockyer.** (Nature, 63. pp. 278–279, Jan. 17, 1901.)—The author points out that, in the case of stellar photographs, it is most important to prevent any fading of the image, as the fainter stars are discernible only in the negative, being lost in the process of reproduction. In some of Roberts's photographs the number of visible star images diminished by 35 per cent. in ten years. Crookes has published, in the monthly notices of the Royal Astronomical Society, a method of reviving these lost images and of preventing further fading. The plate is treated with a solution of pyrogallic acid and sodium carbonate, then with sodium hyposulphite, and after immersing in a clearing solution is toned in an ammonium sulphocyanide gold-toning bath. The deposit of gold is more permanent than the original silver image. G. H. B.

784. *Absorption of Light by Coloured Glass.* **R. Zsigmondy.** (Ann. d. Physik, 4. 1. pp. 60–71, Jan., 1901.)—Definite quantities of colouring oxide were added to ten or more kinds of glass of known composition, manufactured according to the same method at Jena. For these the absorption A was determined by a Glan spectrum photometer, A being taken as E/gS, where E, the extinction coefficient, is the reciprocal of the glass thickness for which intensity of transmitted light is to that of incident light as 1 : 10 ; g is the number of milligrammes of colouring oxide per gm. of glass, and S is the

sp. gr. of the glass. Several good curves with spectra are given, showing the absorption which takes place for varying wave-length for the different colouring materials added, viz., oxides of chromium, copper, cobalt, nickel, manganese, iron, and uranium. G. E. A.

785. *Electric Analogue to the Zeeman Effect.* **W. Voigt.** (Ann. d. Physik, 4. 1. pp. 197–208, Jan., 1901.)—The object of this paper is to show that Lorentz's theory of the Zeeman effect, when applied to direct electro-optical phenomena, leads to the same results as the author's treatment of the inverse phenomenon (see Wied. Ann. 69. p. 297, 1899) by the application of Kirchoff's principle. The well-known effects of a field of electric force on light passing through a transparent medium show that the simple equations in Lorentz's theory, $md^2x/dt^2 = -\kappa x$, &c., where κ is a constant, can only be true as a first approximation. By means of the next approximation to the elastic force $K = (\kappa + \kappa' r^2)r$, it is found that for an ion vibrating in a field of electric force (of amount R parallel to the axis of z) its periods of vibration along the co-ordinate axes are given by the equations—

$$\left(\frac{2\pi}{\tau_1}\right)^2 = \left(\frac{2\pi}{\tau_2}\right)^2 = \frac{1}{m}\left(\kappa + \frac{\kappa' e^2 R^2}{\kappa^2}\right), \quad \left(\frac{2\pi}{\tau_3}\right)^2 = \frac{1}{m}\left(\kappa + \frac{3\kappa' e^2 R^2}{\kappa^2}\right),$$

instead of by the equation $\left(\frac{2\pi}{\tau}\right)^2 = \frac{\kappa}{m}$ in the undisturbed state. Hence it follows from Lorentz's theory that a luminous source vibrating with period τ in an electric field emits in a direction parallel to the lines of force ordinary light of a slightly different period τ_1, but in a direction perpendicular to the lines of force it emits two beams of light, plane-polarised in perpendicular planes, and of periods τ_1, τ_3, where $\tau_3 - \tau = 3(\tau_1 - \tau)$. Thus the author's previous conclusions are confirmed. His previous theory had also led to the expression $D_0 + D_1 R^2$ for the dielectric constant, and for a medium with only one kind of electron (a in number per unit volume) there are now deduced the expressions—

$$D_0 = 1 + \frac{4\pi e^2 a}{\kappa}, \quad D_1 = -(D_0 - 1)\rho_1$$

where

$$\rho_1 = \frac{\lambda_1 - \lambda_3}{\lambda} = \frac{\kappa' e^2 \tau^2}{4\pi^2 m \kappa^2}$$

is the relative separation for unit field. The author applies his results and Quincke's investigations on electric double refraction to an estimation of the order of magnitude of the effect, concluding that, if the fall of potential in the field be 300 volts per centimetre, it might be about the 20,000th part of the interval between the two sodium lines, which would explain why no one has yet been able to observe the phenomenon. W. E. T.

786. *Internal Reflection in a Crystal with Rotatory Power.* **B. Brunhes.** (Archives Néerlandaises, 5. pp. 1–16, 1900.)—The effects of double refraction are here complicated by those of rotation. Quartz plates 2 mm. thick, cut at 45° to the optic axis, were employed. A ray traversing such a crystal in the direction of the axis gives rise to two rays on internal reflection, an ordinary and an extraordinary, and the difference of phase of these two produced by the reflection was examined. Total reflection at air was compared with partial reflection at alcohol. Generally, a ray on striking the crystal would be split into two. Since, for simplicity of result, it was necessary that the

internally incident ray should be unique, matters were so arranged that the entering beam was circularly polarised, and thus able to pass unchanged in the direction of the optic axis. It was found that the difference in phase between the two reflected rays (rectilinearly polarised) was the same for right-handed circular incident vibration as for left-handed. The case of oblique transmission also was investigated, for rays making a small angle with the optic axis. Here special difficulties arise from the fact that one definite elliptic vibration (right or left-handed) has to be given to the incident ray that it may pass in the required direction unchanged. The required ellipticity was determined for several values of the inclination of the ray to the axis. The results of the measures accord fairly well with those of calculations based on the principles enumerated by Gouy (Journ. de Physique, 2e Serie, t. iv., p. 149, 1885). *Apparatus.*—The quartz plate forms the hypotenusal face of a right-angled isosceles liquid prism, whose other two sides are of glass. The liquid is a mixture of two vols. of benzine with one vol. of carbon bisulphide, its index being nearly the same as the ordinary index of quartz. On the side of the crystal, away from the prism, is a shallow chamber for air or liquid, divided in two by a cross partition, so that one half can be filled with air and the other with alcohol, and the reflections against these two media compared. A ray incident normally on one of the lateral faces of the prism emerges from the other after reflection at 45° at the interior surface of the crystal. As to the rest of the apparatus, a small pencil of solar light passes in turn through the following: a circular polariser, an achromatic lens, the prism and quartz where it is reflected at 45°, an analysing nicol, a lens, and the spectroscope. The circular polariser consists of a Nicol followed by a Fresnel's rhomb adjusted so that when the Nicol is set in the azimuth $P = 45°$ or $P = 135°$ the ray entering the prism is circular.

In general, where polariser and analyser have arbitrary orientation, the appearances are complicated. For simplicity, one of the two following plans was adopted: (1) The polariser was set at $P = 45°$ or 135°, and the analyser rotated. Then a score of bands are seen in the spectrum, which remain fixed in position, but alter in blackness or brightness. (2) The analyser was set at $A = 0$ or 90°, and the polariser rotated. Only one, unique, band is seen in the case of transmission parallel to the optic axis. This method was applied to oblique transmission, it being sought to determine for what two values of P the spectral bands had their maximum sharpness. One value is $P = 90°$; the other, $P = \phi$, varied with the incidence. The positions half-way between these give the proper azimuths of the polariser for obtaining a unique ray. By means of the bands in the spectrum, the difference of phase between the ordinary and extraordinary ray caused by passage through the quartz can be measured. In the case of total reflection at air, it was found that in passing from a right-handed circular incident vibration to a left-handed there was no displacement of the spectral bands, or rather the spectra were complementary. A similar remark applies to the two "privileged" elliptic vibrations (right and left-handed) in the case of oblique transmission. In comparing total reflection at air with partial reflection at alcohol a displacement of the bands was observed. For $A = 0$ or 90°, and for $P = 0°$ or 90°, the light emerging from the analyser is coloured, green or purple, according as the nicols are crossed or parallel. Exactly the same tints are obtained by reflection at alcohol as by reflection at air. A. E.

787. *Magnetic Rotatory Polarisation.* **W. Wien.** (Écl. Électr. 25, pp. 114–115, 1900.)—The author criticises Brillouin's contention [see Abstract

No. 1124 (1898)]" that the Faraday effect is no exception to the theorem of Clausius, and that at the same time it is an exception to the law of reciprocity in the path of luminous rays. The author believes that the two theorems of Clausius and Helmholtz cannot be separated. Let ds_1 and ds_2 be two equal elements of black surface which send each other rays. To calculate the radiation from ds_1 to ds_2, a cone is constructed upon every point of the element ds_1, and the radiation is—

$$eds_1 \frac{ds_2}{r^2},$$

where e is a constant and r the distance between the elements. Similarly, the radiation from ds_2 upon ds_1 is—

$$eds_2 \frac{ds_1}{r^2}.$$

These two expressions are equal whatever be the path of the rays, provided it is the same to and fro. But when the plane of polarisation is turned by magnetic forces, the paths are different, and the cones are no longer identical. The author describes a case in which the amount of radiation received by one surface may be three times the amount received by the other. E. E. F.

738. *Rotatory Power of Malic Acid.* **B. Woringer.** (Zeitschr. Phys. Chem. 36. pp. 336–357, Feb. 22, 1901.)—Plotting out the apparent specific rotatory powers as ordinates and the percentages (q) of water in the solution as abscissæ, we find for each colour that the curve is very nearly a straight line. We have for the different colours :—

Red ($\lambda = 665{\cdot}9\ \mu\mu$), $(a) = +4{\cdot}605° - 0{\cdot}071q$.....	$q = 64{\cdot}96$	per cent.
Yellow ($\lambda = 591{\cdot}9\ \mu\mu$), $(a) = +6{\cdot}544° - 0{\cdot}096q$	68·41	,,
Green ($\lambda = 533{\cdot}0\ \mu\mu$), $(a) = +8{\cdot}349° - 0{\cdot}113q$.....	74·02	,,
Bright blue ($\lambda = 488{\cdot}5\ \mu\mu$), $(a) = +10{\cdot}121° - 0{\cdot}130q$	77·95	,,
Dark blue ($\lambda = 448{\cdot}2\ \mu\mu$), $(a) = +14{\cdot}971° - 0{\cdot}173q$	86·56	,,

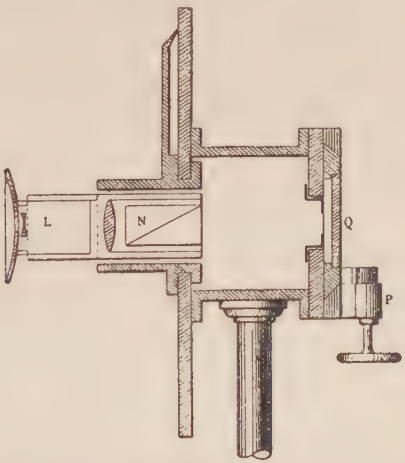
The last column shows the percentages of water in solutions which, for the respective colours, produce no rotation, the rotation for more dilute solutions being negative, to the left. Only wave-lengths shorter than $\lambda = 382{\cdot}0\ \mu\mu$ give positive rotations at all dilutions. The straight lines converge as the dilution increases, but they do not meet at any one point ; there is, therefore, no "complete achromatism" (Nasini and Gennari, Zeitschr. Phys. Chem. 19, 115, 1896) at any dilution. There is, however, partial achromatism : the lines for red and yellow cross, and the rotations for red and yellow are equal, at 78 per cent. water ; red and green at 89, red and bright blue at 93 (red and dark blue at 102 per cent.). At these respective percentages of water anomalies of dispersion appear, the red becoming less rotated to the left than the green, and so on for the others ; so that at infinite dilution (a) has a maximum negative value for the yellow ($\lambda = 540$) not the red. The Biot-Boltzmann formula $(a) = A/\lambda^2 + B/\lambda^4$ is sufficient for $q = 0$, and no terms in λ^6 are required. For each degree of dilution there is one colour the rotation of which is a minimum. In general, for a temperature of 20°,

$$(a) = \frac{1{\cdot}173}{10^9 . \lambda^2} + \frac{0{\cdot}348}{10^{12} . \lambda^4} + \left(\frac{0{\cdot}02901}{10^6 . \lambda^2} + \frac{0{\cdot}000959}{10^{12} . \lambda^4}\right) q.$$

On finding the values of (a) for $q = 0$ and for $q = 100$ we may plot these and draw a straight line between them. The equation last given represents a

surface of the third order, in (a), $(10^6.\lambda^3)$, and q, the geometry of which is discussed; the anomalies referred to above represent a fold in this surface. A. D.

789. *New Half-Shadow Polarimeter.* **J. M. de Lépinay.** (Comptes Rendus, 131. pp. 832–834, 1900. Also Journ. de Physique, Nov., 1900.)—The new apparatus satisfies two conditions essential to precision. It allows of the employment of any monochromatic radiation, and it preserves all its sensibility in converging light. The first condition has been fulfilled by using, for the production of the half-shadows, a thin quartz formed by two prismatic plates with opposite rotations, and with small and equal angles. This enables the observer to produce maximum sensibility whatever the wave-length of the light used. The second condition is of great importance. Since the optical properties of an anisotropic body vary with the direction, the solid examined must be terminated by plane surfaces and the phenomena must be observed by means of an astronomical lens focussed upon infinity. To each point of the focal plane of the object-lens there corresponds a single direction of propagation of the light through the body.



If then the phenomenon utilised is a phenomenon of polarisation, the analyser will be by preference introduced between the eyepiece and the focal plane of the object-lens, and the point of reference will remain fixed during the rotation of the analyser. If the analyser is an ordinary Nicol, all accurate observation becomes impossible, as it is traversed by a divergent beam. This is obviated by making the faces of the Nicol normal to the entering and emerging beam and parallel to the optical axis of the Iceland spar. A small Galilean telescope allows the observer to focus upon the plane of the quartz plate. The arrangement is shown in the diagram, where Q is the quartz plate, N the Ahrens prism which serves as an analyser, and L a Galilean telescope. The author has applied the apparatus to the measurement of the rotatory power of quartz for the green mercury line, and to absolute measurements of thickness by a modification of Mouton's method. E. E. F.

790. *Interference Phenomena.* **C. Barus.** (Science, 12. pp. 617–627, 1900.)—The author writes on the interferences observed on viewing one

coarse grating through another, and on the projection of one piece of wire gauze by a parallel piece. The investigation was suggested by the common phenomena of waterlines seen on looking through two parallel picket fences, but these turn out to be very complex, and open to careful analytical treatment. If two gratings are placed at a distance apart along an axis, and the first illuminated by a strong diffuse light, the second will project a real image of the former grating at definite points on the axis, almost as if it were a zone plate. When these images are looked at by the eye in the proper position, they appear as magnifications of the first grating, often enormously large, the size increasing with the distance of the focal plane from the projecting grating. The indefiniteness of focus when viewed by the normal eye is due to its power of accommodation, and the size is an illusion, for the eye is adjusted for an infinite distance and locates the image of unknown position there. Direct projection is only possible in a darkened room and at the strongest focus, supposing that diffused daylight illuminates the first grating. With sunlight all the real foci may be projected, but the use of sunlight slightly alters the conditions. The author describes an arrangement for finding the focal planes by means of a lens placed in front of the eye, and also a diagram in which planes are laid through pairs of wires and their intersection in lines beyond the gratings give rise to the darkest spaces. The focal planes are distributed along the axis at distances of $\frac{1}{2}$, 1, 2, &c.; multiples and submultiples of the distance of the gratings apart when the two gratings are identical. The shadows cast may be 100 feet in length, while in sunlight a filamentary wire will only have an effective shadow 5 or 10 inches long. This is explained by diffraction. E. E. F.

791. *Anomalous Dispersion of Cyanin.* **R. W. Wood** and **C. E. Magnusson.** (Phil. Mag. 1. pp. 36–45, Jan., 1901. Paper read before the Physical Society of London.)—Some experiments on the Anomalous Dispersion of Cyanin were made some time ago by one of the authors [Abstract No. 661 (1899)], but the prisms used did not permit of readings being taken in the absorption band. By working with prisms of angle about 30°, readings have now been obtained throughout the absorption band and also in the ultra-violet, and a second absorption-band has been discovered, beginning at wave-length 0·00037 in the ultra-violet. The prisms were prepared by pressing fused cyanin between optically worked glass surfaces by means of a screw press in a heated air-bath, and then breaking off one of the glasses when cool. Both spectrometer and interferometer methods were used, the latter with thin films of the dye instead of the thin prisms. In the ultra-violet the measurements were made photographically, and in all the experiments monochromatic light was obtained by means of a Rowland grating. The paper is accompanied by curves and photographs showing the dispersion. J. B. H.

792. *Spectrum of Silicon.* **J. N. Lockyer.** (Roy. Soc., Proc. 67. 403–409, Jan. 19, 1901.)—Continuation of the work previously undertaken on the high-tension spark spectrum of silicon [Abstract No. 1022 (1900)] has resulted both in better determinations of the lines formerly seen and the discovery of several new ones. These latter are also found to agree with lines in stellar spectra, and the presence of all the silicon lines in the spectra of the stars α Cygni, β Orionis, γ Orionis, and ϵ Orionis is shown by a tabular statement giving the relative intensities in each case.

Four groups of lines are now recognised, each associated with a distinct temperature level when produced under laboratory conditions, and these data are applied to the plan of classifying stellar spectra into cyclical groups showing evolution of one class from neighbouring ones. C. P. B.

793. *Reversing Layer Photographed with a Concave Grating.* **J. F. Mohler** and **F. C. Daniel.** (Astrophys. Journ. 12. pp. 361-365, 1900.)—Account of an experiment made at the Solar Eclipse, May, 1900. A Rowland grating of 10 feet radius, with 14,400 lines to the inch, was used to form a diffracted image of the sun's crescent without the use of lens or slit, in the same way that an objective prism spectroscope is used. The lines of the grating were tangential to the sun's edge at the places of second and third contact. The sun's image was 0·56 inch in diameter. The partial success obtained leads the authors to believe that the instrument could be used to great advantage in photographing the spectrum of the flash. The results, however, were not so good as had been expected. About forty bright lines were obtained at the flash, but they were lacking in sharpness, and could only be measured to one Ångström unit. The blurring is ascribed partly to insufficient care in adjustment, partly to astigmatism. The effect of the latter is calculated from Mitchell's formula (Johns Hopkins Circular, June, 1898). A. E.

794. *False Spectra with Rowland Concave Grating.* **T. Lyman.** (Phys. Rev. 12. pp. 1–13, Jan., 1901.)—The author finds that several gratings he has used show abnormal spectra, which might be mistaken for true lines, falling in series with the lines of the normal spectrum. Photographs are given showing some of these false images in the spectrum of magnesium. The false lines are not so prominent in large gratings as in smaller examples. The author presents the following conclusions :—

(1) The first spectrum from the Rowland concave grating is not pure, but is complicated not only by underlying spectra of higher order, but by the presence of a number of spectra of lower dispersion than in the chief spectrum.

(2) The number and dispersion of these false spectra obey no simple law and differ with different gratings. C. P. B.

795. *Reproduction of Diffraction Gratings.* **Elihu Thomson.** (Science, 13. pp. 114–115, Jan. 18, 1901.)—This is a comment on a previous letter of R. W. Wood to the same journal, concerning the production of copies of diffraction gratings in bichromated gelatine and albumen. The method followed by Thomson is to silver a glass grating, then copper it electrolytically and separate by slightly warming. The surfaces of the metal copies are not perfectly plane. The author suggests a method of overcoming this. First silver the glass grating, then, having coated a flat glass surface with a thin layer of adhesive cement, like hard pitch or shellac warmed, or with a cement like glycerine and litharge which sets firmly, apply this to the silver surface and allow it to harden before separating from the glass. C. P. B.

796. *Transformations of Röntgen Rays.* **G. Sagnac.** (Soc. Franç. Phys., Bull. 157, pp. 2–3 ; Discussion, p. 3, 1901.)—The amount of secondary radiation gives a clue to the presence of active elements, such as iron or copper in aluminium. The absorption of secondary rays by the air is emphasised by the results of working *in vacuo*. Discussion of phenomena of discharge by air apparently ionised through the travel of ions, slow but analogous to the travel of particles in kathode rays. A. D.

797. *Energy, &c., of Röntgen and Becquerel Rays.* **E. Rutherford** and **R. K. McClung.** (Roy. Soc., Proc. 67. pp. 245–250, Nov. 14, 1900. (Abstract). Roy. Soc., Phil. Trans. 196. pp. 25–59, Feb. 27, 1901.)—On the assumption that all the energy of Röntgen rays is absorbed in producing ions in a gas, the total energy of the rays, divided by the total number of ions produced, would be a measure of the energy required to produce an ion. The energy of the rays was determined by means of the heating effect of a known proportion of these rays absorbed by a metal, a specially designed platinum bolometer being used. It appeared that the correction due to secondary rays was small, and that the assumption was justified that the energy of the rays stopped by the metal plate is transformed into heat in the plate. The number of ions was computed from the current produced by the ionisation of a known volume of the gas and the absorption of the rays in the gas, together with J. J. Thomson's value of the ionic charge. For the special bulb employed the total heating effect due to all the rays emitted from the front of the plate (omitting absorption in the glass, air, and screens) was 0·011 gramme-calorie per second; which, at 57 discharges per second and a duration of 10^{-4} second (Trouton, Brit. Assoc. Report, 1896) for the production of the rays at each discharge, gives a rate of emission of energy (while it lasts) of 1·95 gramme-calorie per second. (Compare the heating effect of sunlight normally incident, 0·035 gramme calorie per second). About 4·4 per cent. of the energy supplied by the rays was transformed into light by a platinocyanide barium screen, and 73 per cent. was absorbed by it. This enables the energy of the radiation of any particular bulb to be expressed in absolute measure by comparing the intensity of the light from the screen with that from a Hefner standard lamp, and measuring, electrically or photometrically, the absorption of the rays by the screen, by placing a portion of the screen to absorb the rays. If H is the number of calories given out per second by the rays, E the energy of the same in ergs per second, W the average amount of energy required to produce an ion, n the number of ions produced per second (supposing all the energy of the rays absorbed in the gas is due alone to the production of ions, either directly or through secondary radiations in the gas), i the maximum or saturation current through the gas when all the ions produced reach the charged electrodes before appreciably recombining, and ϵ the charge on an ion, we have $E = JH$, $nW = E$, and $i = H\epsilon$, whence $W = JH\epsilon/i$. In this $\epsilon = 6{\cdot}5 \times 10^{-10}$ electrostatic unit (J. J. Thomson); and H and i have to be found. The latter, i, cannot be directly measured, since the rays could traverse several hundred metres of gas before approximately complete absorption took place: but it can be calculated from the number of ions produced in a known small volume, together with the coefficient of absorption of the gas. The latter was ascertained by a null method. The absorption is approximately proportional to the pressure: and the coefficient (mean) is, in air, about 0·000279 per atmosphere pressure with the bulb employed (0·001 with a much softer bulb; 1·600 for uranium rays; 0·000457 in carbonic acid, with the bulb employed). The mean value of W, the energy required to produce an ion in air at atmospheric temperature and pressure, is $1{\cdot}90 \times 10^{-10}$ erg: twice this for a positive and a negative ion. The mean intensity I_1 of the radiation at the surface of the bolometer is given by $JH = 0{\cdot}98\ AI_1(1-\rho_1)$, where A is the area of the grid, and ρ_1 is the transmission ratio of the rays when passing through the platinum grid; which gave a mean value $I_1 = 127$ ergs. In carbonic acid the coefficient of absorption was 1·59 times what it is in air; the current (at 300 volts) was 1·43 times as great; the value of W for carbonic acid is $1{\cdot}59/1{\cdot}43 = 1{\cdot}11$ times what it is in

air, but this is subject to corrections, which make the two values of W not very different from one another. Experimental results hitherto obtained tend to show that approximately the same energy is required to produce an ion whatever the gas. Like the absorption, the intensity of the ionisation is proportional to the pressure of the gas. The energy used up in the production of ions in an "electric wind" is about $\frac{1}{6}\frac{1}{5}$ of the whole. The distance between the ions in a molecule works out at about $1{\cdot}1 \times 10^{-9}$ cm., about $\frac{1}{3}\frac{1}{0}$ the diameter of an atom. The energy required to produce an ion in air is very much greater than that required to produce an ion in the electrolysis of water; about 60 times as great: so that in water the ions separated would be about two atoms apart. In regard to sparking, if V be less than 175 volts, more energy would be required to produce ions than would be supplied; this would therefore be a minimum sparking potential. But we cannot infer the energy required to produce an ion from the observed minimum potential: the phenomenon is too complex. The energy emitted per sq. cm. of uranium oxide surface is approximately 10^{-11} calorie per second; per gramme about 10^{-9} calorie per second. Thoria $1{\cdot}2 \times 10^{-11}$ per sq. cm. per sec., in addition to the energy of temporary radio-activity developed on all substances in its neighbourhood. Radium and polonium vary very much from sample to sample, not only as regards the intensity but also as regards the kinds of radiation: uranium seems constant, even in solution or chemical combination, and on recrystallisation in the dark. Probably the radio-activity of uranium is not confined to the surface, but is possessed by the whole mass of the substance. In ten million years, each gramme of uranium in pitch blende must have radiated at least 300,000 calories; and radium far more. To consider these substances as transformers of energy leads to many difficulties. Possibly the regrouping of the components of a molecule might explain the supply of energy: but hardly in the case of radium, should it prove to be persistent in its radio-activity. Whether this is so is not yet known. A. D.

798. *Bolometry in Vacuo.* **F. Kurlbaum.** (Phys. Zeitschr. 2. pp. 258–259, Jan. 26, 1901.)—With reference to the work of Rutherford and McClung [see preceding Abstract], and of Schöps on the determination of Röntgen radiation in absolute units, the author remarks that he had used the same methods (Wied. Ann. 65. pp. 746–760, 51. p. 591), and recalls that he had (Wied. Ann. 61. p. 419) pointed out the advantages of working *in vacuo*. Through (1) eliminating the loss of heat by air-conduction, (2) steadying the apparatus by eliminating air-currents, and (3) reducing the loss of heat to one-twentieth where the radiations impinge on polished platinum in the absence of air, the apparatus is made nearly fifty times as sensitive. The authors referred to would seem to have overlooked this advantage. A. D.

799. *Energy, &c., of Röntgen and Becquerel Rays.* **E. Dorn.** (Phys. Zeitschr. 2. p. 218, Jan. 5, 1901.—In reference to Rutherford and McClung's paper [see preceding Abstracts] the author refers to the work of himself (Wied. Ann. 63. 160, 1897), of Schöps (Zeitschr. für Naturw. 72. 145, 1899, bolometric method) and Moffat (Roy. Soc. Edin., Proc. 21. 430, 1898). Schöps's results are very similar to those of Rutherford and McClung. [In the full R.S. paper, R. and McC. refer to Dorn and Moffat.] A. D.

800. *De-ionisation of Air.* **E. Dorn.** (Phys. Zeitschr. 2. pp. 238–239, Jan. 19, 1901).—A suggested explanation of Villari's experiments [see Abstract

No. 1803 (1900)] on the de-ionisation of air (previously ionised by Röntgen rays) by passing it through a twisted metallic tube. The explanation is based on the difference which, according to J. Zeleny [see Abstract No. 2420 (1900)], exists between the velocities of the positive and negative ions.

D. E. J.

REFERENCES.

801. *Extension of Laplace's Theory of Atmospheric Absorption of Starlight.* **A. Gleichen.** (Deutsch. Phys. Gesell., Verh. 2. 16. pp. 222–234, 1900.)

802. *The Connection between Refraction and Parallax.* **E. v. Oppolzer.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 578–582, 1900.)—The astronomical refraction is the correction which must be applied to the apparent distance in order to obtain the value which would be found supposing the earth's atmosphere absent. The author discusses the expression for this quantity and its connection with parallax, and calculates the small correction which must be made in the parallax of the moon with various values of the apparent zenith distance, on account of refraction.

J. J. S.

803. *Stresses in Solid Bodies due to Unequal Heating, &c.* **Rayleigh.** (Archives Néerlandaises, 5. pp. 32–42, 1900.)—Paper similar to that referred to in Abstract No. 778 (1901).

804. *Theory of Two Lens Objective.* **K. Strehl.** (Zeitschr. Instrumentenk, 21. pp. 10–11, Jan., 1901.)—The optical problem solved in this paper is as follows:—Suppose the distances of the object and image from a two lens objective to be given, suppose also the kinds of glass to be fixed and the lenses to be of infinitesimal thickness; it is required to find the four radii of curvature of the faces to satisfy the usual equations representing the chromatic, spherical, and sine conditions.

J. B. H.

805. *Light without Heat.* **R. A. Fessenden.** (Elect. World and Engineer, 37. pp. 24–26, Jan. 5, 1901.)—An interesting discussion of the present methods of producing light, concluding with a reference to the possibility of producing a cold light by chemical means.

W. R. C.

HEAT.

806. *Expansion of a Hard Jena Glass.* **J. T. Bottomley** and **W. T. Evans.** (Phil. Mag. 1. pp. 125–128, Jan., 1901.)—The authors describe experiments which were rendered necessary by the construction of an air-thermometer of the Bottomley type, which should be capable of being used at high temperatures, above the softening point of ordinary English glass. The glass used for the volume-gauge was a very hard Jena glass, supplied by Messrs. Schott and Co. and termed by them "Verbrennungsröhrenglas." The cubical expansion of the glass was determined directly by the weight-thermometer method, the particular form of apparatus used being fully described. The results of several experiments gave for the cubic expansion the values 0·00177, 0·00182, 0·00183, 0·00181; and this very small expansion makes this particular glass specially suitable for thermometric purposes at high temperatures. W. C. H.

807. *Thermal Absorption by Atmospheric Water-vapour and Carbon dioxide.* **K. Ångström.** (Ann. d. Physik, 3. 4. pp. 720–732, 1900.)—The author made experiments at various altitudes in Teneriffe, to determine the absorption of the sun's rays by carbon dioxide. Two tubes 40 cm. long, closed by plates of rock-salt, were fixed side by side, one containing air and the other carbon dioxide. At one end of each was placed a thermo-junction, the two being connected in series and in opposition, so that no e.m.f. would be produced if the radiation through the two tubes was the same. The carbon dioxide tube never showed any absorption, though an absorption of 1·5 per cent. was capable of measurement. From Lecher's results an absorption of 6 per cent. was to have been expected. The author calculates the absorption of the earth's radiation from the curves of distribution of energy in the spectrum. Assuming the constant e in Wien's equation as 14,700, he draws curves for temperatures of 100°, 8° and — 72° C., and measures the areas of the carbon dioxide absorption bands at 14·0–15·5 μ and at 4·18 μ. For a source of heat at 100° C., the absorption would be from 12·5 to 19 per cent. of the whole radiation; the author concludes that the maximum possible absorption of the earth's radiation would be 16 per cent.

The author next measured the absorption by various thicknesses of water at altitudes of 360 m., 2,125 m., and 3,683 m. above the sea. The equivalent thicknesses of water at these altitudes were respectively 2·6 cm., 1·2 cm., and 0·7 cm. From Hann's equation he finds the transmission coefficient to vary from 0·952 to 0.976. Schukewitsch's measurements of the absorption yield transmission coefficients varying from 0·961 to 0·991. Calculations from the differences between the sun's actual spectral curve and its curve if radiating according to Wien's law show an absorption of from 20 to 30 per cent.

G. H. B.

808. *Position of the Volume- and Energy-Surface of a Crystal and its Melt.* **G. Tammann.** (Archives Néerlandaises, 5. pp. 108–117, 1900.)—To determine the position of the curve in which the volume-surfaces of a crystal and its melt intersect, it is necessary to measure the differences of the two specific heats of the substance not only for points near the melting-point curve but

also for the super-cooled liquid. For this purpose the author chooses benzophenone, which possesses the property of spontaneous crystallisation in only a small degree. The results of the measurements carried out are briefly as follows :—(1) The change of volume on crystallisation of benzophenone at 44·7° is found to be (*a*) 0·0914 and (*b*) 0·0936 c.c. per c.c. or, taking the specific gravity of the liquid at 44·7° as 1·0988, 0·0832, and 0·0852 c.c. per gramme of material ; the second value is probably nearer the truth than the first. (2) The isobaric curves of the crystal and its melt for a pressure of 1 kg. per square cm. intersect at about −83°. (3) The connection between pressure in kg. per square cm. and melting-point of benzophenone is expressed very nearly by the equations—

$$p = 36{\cdot}45\ (t - 48{\cdot}1) + 0{\cdot}087\ (t - 48{\cdot}1)^2.$$

or—

$$t = 48{\cdot}14 + 0{\cdot}02757p - 0{\cdot}00000136p^2.$$

(4) The change of volume Δv on the melting-point curve diminishes proportionally as the temperature increases ; $\Delta v = 0{\cdot}0833 - 0{\cdot}00044\ (t - 48{\cdot}1)$. (5) The latent heat of fusion of benzophenone increases by 0·2 per cent. per 1°, while the change of volume on melting diminishes by 0·5 per cent. per 1°. (6) The isothermal variations of Δv are, other conditions being equal, larger than the variations of Δv on the melting-point curve, and diminish as the temperature falls. From the data obtained the author shows how the projection of the curve of intersection of the two volume surfaces can be approximately traced. T. H. P.

809. *Unit of Thermal Capacity.* **T. W. Richards.** (Zeitschr. Phys. Chem. 36. pp. 358–360, Feb. 22, 1901.)—The word "calorie" has become of uncertain meaning in the absence of an explanation on each occasion, on account of the variations in the specific heat of water. The expression of heat in c.g.s. units is hampered by this, that the unit of temperature has no relation to the c.g.s. system. The ideal would be—(thermal capacity $\times\ \delta\tau$) = Joules. It would not be convenient to graduate thermometers in degrees each about $\frac{1}{4{\cdot}2}$°C. ; for the graduation would have to be altered at each determination of the mechanical equivalent of heat. If we took, instead of a gramme of water, a gramme of magnesium for temperatures about −50°, or a gramme of aluminium for about 290°, or a gramme of magnesium containing about 5·5 per cent. Zn for ordinary temperatures, we would have a unit of capacity equal to about $\frac{1}{4{\cdot}181}$ calorie, which might be called a "Mayer," the c.g.s. Centigrade unit. This would work out well in detail, with the aid of a kilomayer (*kmy*) and would be useful not only in entropy but also particularly in electrochemical problems. A. D.

810. *Melting-Point of Gold.* **L. Holborn** and **A. Day.** (Ann. d. Physik, 4. 1. pp. 99–103, Jan., 1901. Communicated by the Phys. Tech. Reichsanstalt.)—The results are given of several series of determinations of the melting-point of a mass of 450 grammes of pure gold by the crucible method. The gold was heated by means of an electric furnace, the temperature being measured by the same thermo-element as was previously used by the authors in determining the melting-point of gold by the wire-method, in which 1 cm. of gold wire was fused at the junction of the thermo-element. The mean values of the melting- and solidifying-points for the different series are as follows : (1) Using an ignited graphite crucible with walls 5 mm. thick, 1065·5°. (2) The same as (1), but with a current of carbon dioxide passing

into the metal, 1063·5°. (3) Using a double porcelain crucible with asbestos packing between, 1063·3°. (4) Same as (1) or (3), but with a current of oxygen passing into the metal, 1063·5°. The curves showing the alteration of temperature with time do not show very good agreement. This is especially noticeable when oxygen is passed into the gold, in which case the stationary condition is by no means well defined, but the temperature rises considerably above the melting-point, to which it falls later. A piece of the gold used in the above measurements was drawn out into wire and employed for the determination of the melting-point by the wire method, the mean value obtained being 1063·9°. T. H. P.

811. *Automatic Temperature Regulator.* **C. T. Knipp.** (Phys. Rev. 12. pp. 47–49, Jan., 1901.)—An oven was electrically maintained at a constant temperature up to 380° C. for days together by two radiator coils, the fine adjustment of temperature being controlled by a copper iron thermostat. The temperature acts through a number of aluminium levers upon the contact of a relay. A curve of temperature fluctuations is given. M. O'G.

812. *Comparison of Thermometers of Different Glasses.* **F. Grützmacher.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 229–268, 1900.)—A comparison is here made between eighteen thermometers, made between the years 1825 and 1888 by well-known makers. The experiments have extended over seven years to ensure that no continuous creeping of the zero points was taking place. The depression of the ice-point is determined for each thermometer after being kept for considerable time intervals at constant temperatures up to 100° C. The thermometer scales are also compared with the hydrogen scale.

The chemical compositions of the glasses are then compared, with the view of finding what constituents cause the greatest deviations from the hydrogen scale, and the greatest ice-point depressions. It appears that glasses which contain both potassium and sodium oxides are bad, and the more the proportion of these oxides present tends towards equality, the worse the glass becomes. The amounts of the reduction to the hydrogen scale and the depression of the ice-point seem to depend similarly on the chemical constituents of the glass, so that a determination of the ice-point depression suffices to measure the suitability of a glass for thermometric purposes. The best glass for thermometric purposes among those tested is the Jena glass No. 59^{III}. J. B. H.

813. *Capillary Error in Mercury Thermometers.* **C. E. Guillaume.** (Soc. Franç. Phys., Bull. 159. p. 3; Discussion, pp. 3–4, 1901.)—The angle of contact of the meniscus with the glass is found to depend upon the direction of the change in temperature. If, after a lowering of the level of the mercury, a feeble rise in temperature occurs, the angle of contact changes and the meniscus may not be displaced, the capillary pressure being altered, and therefore the volume of the bulb being so changed as to mask the increase in the volume of the mercury. Determinations of the amount of the error for various places in the tube show that variations in the error are due to differences in the surface of the glass. Owing to this error it is useless to increase the length of the degree beyond a certain limit.

In the discussion **Ponsot** referred to direct determinations of the correc-

tion for internal pressure made from readings taken with the thermometer alternately vertical and horizontal. The maximum of the curve of this correction agreed with the places where the equivalent lengths were greatest in the tube, and therefore he concluded that there was no capillary error of sensible amount arising from the variation of capillary pressure. In reply, **Guillaume** insisted on the necessity for applying to observations the correction for calibration before submitting them to other calculations. W. E. T.

814. *Pyrometry.* **C. Barus.** (International Physical Congress at Paris, Report, 1. pp. 148–177, 1900. Part reprint from the Bull. of the U.S. Geological Survey, Washington, 1889.)—A historical account is given of the methods of pyrometry, especially the recent devices for the accurate measurement of very high temperatures. The important researches by Holborn and Wien, and by Holborn and Day are referred to. For temperatures of 1,000° or over, the correction required in the stem of the porcelain air thermometer is doubtful.

The author discusses the errors inherent in the air thermometer at constant volume, and those belonging to the constant pressure air thermometer, and then refers to Regnault's gas thermometer depending on displacement, and to the attempts of Barus and Callendar to utilise the increase of the viscosity of gases. The viscosity being independent of the pressure, whilst viscosity and volume both increase with temperature, the velocity of passage of gases across tubes of platinum is a criterion doubly sensitive to variation of temperature.

Optical methods and electrical instruments are then described, and in conclusion the author states that the present condition of pyrometry is most encouraging, and that in a few years it will possess a series of constants as exact as those of the best developed branches of Physics. Nernst has discovered that refractory earths become conductive at high temperatures, so that it has become possible to heat electrically the most infusible substances up to the highest points of the scale. J. J. S.

815. *Latent Heats of Vaporisation of Organic Compounds.* **W. Louguinine.** (Comptes Rendus, 132. pp. 88–89, Jan. 14, 1901.)—The following are the mean results of the author's measurements of (1) Specific Heats : Aniline, 0·5485 (between 20·5° and 176·5°) ; methylethylacetoxime, 0·6503 (between 21·9° and 151·5°) ; anisol, 0·4806 (between 20° and 151·7°) ; butyronitril, 0·5471 (between 21° and 113·8°). (2) Latent Heats of Vaporisation : Aniline, 104·17, which gives a value of 21·19 for Trouton's ratio of molecular latent heat to the absolute boiling-point ; methylethylacetoxime, 115·73, the corresponding value for Trouton's formula being 23·7 ; anisol, 80·30, giving 20·58 for Trouton's formula ; butyronitril, 115·25, Trouton's number being 20·37. The values obtained for Trouton's formula show that in the case of aniline, anisol, and butyronitril, the liquid molecules are not polymerised to any appreciable extent, whilst the high value obtained for methylethylacetoxime indicates that its liquid molecule is polymerised to a considerable degree. Experiments previously carried out on alcohols and organic acids show that molecules containing a hydroxyl group in combination with a carbon atom suffer polymerisation in the liquid state, and the fact that the same is found to hold in the case of methylethylacetoxime shows that polymerisation also occurs with liquid molecules in which there exists a hydroxyl group combined with a nitrogen atom. [See also Abstracts Nos. 921 (1898), and 1038 (1900).]

T. H. P.

816. *Vapour Pressure of Water between* $-12°$ *and* $+25°$. **M. Thiesen** and **K. Scheel.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 71–94, 1900.)—This is the first of a series of investigations into the pressure of saturated water-vapour at different temperatures undertaken by the Reichsanstalt. The object of the present investigation was to determine the vapour pressure at 0 C., but some readings were also taken at temperatures varying from -12 up to $+25°$ C.; these determinations, however, have not the same accuracy as that for 0°.

The method adopted is a direct manometric one, the water at the required temperature being in communication with one limb of the manometer and the other limb being connected with a vessel containing phosphorous pentoxide. The whole apparatus was carefully exhausted so that only water vapour was present. The method adopted for reading the level of the mercury surfaces in the manometer was that used in a former investigation [see Abstract No. 479 (1901)], and consisted in measuring microscopically the distance between a mark on the glass and its image in the mercury surface. It is quite impossible to give here the details of the investigation and the precautions taken, which were of that supreme order common to Reichsanstalt work.

The final result for the pressure of saturated water vapour at 0° C.

$= 4{\cdot}579 \pm 0{\cdot}001$ mm. of mercury at 0° and normal gravity.

$= 0{\cdot}006025$ atmospheres.

The means of the other observations are as follows:

Temperature.....	14·5679	15·0593	19·8402	16·3603	19·8438	25·4748	24·9749	−6·561	−11·334
Pressure.....	12·4385	12·8285	17·3622	13·9189	17·3411	24·3308	23·6818	2·6731	1·9217

These numbers are compared with a formula deduced in a previous paper by one of the authors [see Abstract No. 806 (1899)]. J. B. H.

817. *Determination of Specific Heats.* **W. Louguinine.** (Journ. de Physique, 10. pp. 5–19, Jan., 1901.)—The apparatus described, which is suited for the determination of the specific heats of both solids and liquids, is a modification and development of Louguinine's oven for use with the ice calorimeter (see Annales de Chemie et de Physique, 5e series, vol. xxvii. p. 398). In most calorimetric processes the method adopted is the following: The oven and boiler being fixed to bring the calorimeter up to them, allow the substance to drop from the oven into the calorimeter, and then remove it out of the range of possible radiations from them. In the instrument of Louguinine the calorimeter remains fixed, while the oven (and with it the boiler) can be brought up by means of a car running smoothly upon a pair of rails, which allow of its being removed to a distance of over a meter from the calorimeter when required.

When an observation is to be made by the former method, the temperature of the water in the calorimeter must be taken, the stirrer detached from the apparatus which keeps it in motion, the calorimeter brought up to the oven, the substance received in it, the calorimeter returned to its former position, the stirrer again attached, and finally the temperature read upon the thermometer placed in the water. There is a possibility of the water being cooled during its passage through the air, which must of necessity be fairly rapid, as the operation has to be done in as short a time as possible; there is a chance of spilling the water in the transit, and the time taken to attach the stirrer is also a drawback. With Louguinine's instrument, where the required

temperature has been attained in the oven, it is run up on its rails so that its central cavity in which the substance under experiment is lying stands directly over the calorimeter. The thermometer in the calorimeter being watched all the time, and the stirrer keeping the water in motion, the substance can be allowed to drop into the calorimeter from the oven by pressing a button, the door at the bottom of the oven opening automatically to allow it to pass ; the oven is then at once removed, and the indications of the thermometer carefully noted.

To the car which carries the oven are also attached a boiler and a condenser for the heating substance, the condensed vapour being returned again to the boiler. As heating liquids, various substances may be used according to the temperature required.

The substance under experiment, if solid, is made into an ovoid shape ; if liquid, it is placed in a vessel of platinum of known capacity for heat, and also of an ovoid shape, to avoid splashing of the water as it drops into the calorimeter. Diagrams of the apparatus are given showing its minute construction, and tables of results obtained with it are also shown.

W. C. O.

818. *Molecular Heat of Compounds, and the Law of Neumann, Joule, and Kopp.* **E. van Aubel.** (Journ. de Physique, 10. pp. 36–37, Jan., 1901.)—Meyer's statement [Abstract No. 1434 (1900)] that the molecular heat of a compound is equal to, greater, or less than, the sum of the atomic heats of the elements according as the molecular volume is equal to, greater, or less than, the sum of the atomic volumes, does not hold in the case of AgBr and KI, which have a smaller molecular volume but a larger molecular heat ; nor in the case of mercurous and mercuric iodides, which have a larger molecular volume but a smaller molecular heat. Amongst alloys that of antimony and iron, which is formed with a decrease of volume, shows an increase of heat capacity. T. M. L.

819. *Specific Heat of Gases.* **A. Battelli.** (N. Cimento, 12. pp. 300–314, 1900 ; Intern. Phys. Congress at Paris, Report, 1. pp. 682–696, 1900,)—Both C_p and C_v vary considerably with the pressure : references are made to Joule and Thomson, Lussana, Leduc, Donnini, De Heen, Margules, Joly, Witkowski, Linde, Amagat ; the law of the variation is still obscure, but there appears to be a maximum value of C_p at 350 atmos. (Amagat), 395 (Lussana). At constant pressure the specific heat also varies with the temperature (Lussana, Joly, Witkowski, E. Wiedemann, Winkelmann, Wüllner). Variations in vapours, hydrogen in palladium, the ratio C_p/C_v, and the velocity, &c., of sound are referred to along with the work of numerous investigators ; as to the variations of C_p/C_v with temperature and pressure the results (Müller, Kundt, Wüllner, Cohen, Leduc) seem discordant but appear to show that there are variations of which the law is still obscure. A. D.

820. *Determination of Critical Constants.* **É. Mathias.** (International Physical Congress at Paris, Report, 1. pp. 615–667, 1900.)—This paper contains a valuable account, descriptive and critical, of the various methods which have been employed for the determination of any or all of the critical constants of homogeneous substances and of mixtures. It is followed by a note on the optical method, and the phenomenon of Cagniard-Latour. The author shows that the fact that the meniscus between a liquid and its saturated vapour disappears at various mean densities, the ratio of the volumes (v and

v') of the liquid and vapour differing from unity, proves the necessity of introducing the notion of the Cagniard-Latour phenomenon into the theoretical calculation of v/v'. The formula then arrived at shows that for substances, whose mean densities have corresponding values, the phenomenon occurs at corresponding temperatures for which the ratio v/v' is the same, and suggests a new method of obtaining accurately the critical density and temperature, dependent on an approximate knowledge of the latter and on the measurement of v/v' when the meniscus disappears. The author estimates the possible error in the method, points out the special precautions to be adopted in its use and various questions worthy of experimental study, and shows its advantages over the similar method of Stoletov (Phys. Revue de Graetz. t. ii. pp. 69–73, 1892). In conclusion he shows that if the temperature at which the meniscus vanishes be a function of the mean density of the body in the tube it cannot be a function continually increasing or continually diminishing. W. E. T.

821. *Specific Heats of Fluids.* **P. Duhem.** (Comptes Rendus, 132. pp. 292–295, Feb. 11, 1901.)—The author considers the elements of a fluid as subject to general mutual reactions, and extends to this case the ordinary thermodynamical theorems. Thus, for a fluid in stable equilibrium, he proves the specific heat at constant pressure greater than that at constant volume and demonstrates the equations in the ordinary notation,

$$\left(\frac{dv}{dp}\right)_\phi = \frac{C_v}{C_p}\left(\frac{dv}{dp}\right)_T$$

and, for an adiabatic transformation,

$$\delta T = \frac{T}{JC_p}\left(\frac{dv}{dT}\right)_p \delta p.$$

W. E. T.

822. *Theory of Radiation.* **W. Wien.** (Ann. d. Physik, 4. 2. pp. 422–424, Feb., 1901.)—Planck's criticism of the author's former paper is here dealt with [see Abstracts Nos. 504 and 505 (1901)]. The difference between the writers disappears when a strict definition of an irreversible process is given. The problem of the radiating element at the centre of a reflecting hemisphere is strictly reversible if the element has infinitesimal dimensions. If, however, the element has finite dimensions, then the paths followed by all rays between the two spherical surfaces will not be equally long and the conditions at the instant of removing the inner sphere will be only approximately realised periodically, but if sufficient time is allowed the approximation may be as close as one pleases.

With regard to the problem of the magnetic rotation and the seeming contradiction of the second law of thermodynamics, the author considers that a strict investigation of the total radiation from the two bodies is desirable.

Jahnke, Lummer, and Pringsheim have objected to the author's suggestion to separate the law of radiation as applied to short and long waves. The author considers that deviations from the theoretical law, which is founded on molecular hypothesis, must occur with increase of temperature at smaller and smaller wave-lengths, and that with sufficient rise of temperature, those effects, which cause the deviations for long waves at low temperatures, can be made to affect any wave-length. J. B. H.

823. *Distribution of Energy in the Spectrum of a Black Body.* **E. Jahnke, O. Lummer,** and **E. Pringsheim.** (Ann. d. Physik, 4. 1. pp. 225–230, Jan., 1901.)—Critical discussion of Wien's formula; conclusion that the same is not in accord with the facts, is not well founded, and implies a temperature function which it is supposed to be devoid of. A. D.

824. *Formula for Pressure in a Gas.* **L. Boltzmann.** (Archives Néerlandaises, 5. pp. 76–77, 1900.)—If the volume actually occupied by gas molecules does not vanish in comparison with the space in which their motion takes place, the formula for the pressure, which for molecules of infinitely small dimensions would be T/v, requires a correction, which van der Waals expresses by using $v-b$ for v. Boltzmann refers here to Lorentz's treatment of the same subject, and to his own treatment in the Vorlesungen über Gas Theorie, Part II. pp. 7 and 167. He says here that his own method gives a complete value for the second term in the correction. But the integration being heavy is not yet completed. S. H. B.

825. *Theory of Gases.* **M. Reinganum.** (Phys. Zeitschr. 2. pp. 241–245; Discussion, p. 245, Jan. 19, 1901. Paper read before the 72nd Naturforscherversammlung at Aachen.)—Some difficulties may, it is suggested, be got over by the following theory:—Assume (1) the impacts between molecules are elastic and practically momentary; (2) the attractive forces are continuous but are negligible at any measurable distances, and are also independent of the mutual velocities; (3) these forces only come into play when molecules are at close quarters, the more so the greater the pressure, in which case the compensation of such forces all round a molecule begins to apply; (4) the deviation of molecules by attractive forces is less the higher the temperature; (5) the sum of the energies of the molecules remains constant. On this basis we find—

$$\left(p+\frac{f(c/T)}{v^2}\right)\left(v-be^{c/T}\right)=RT,$$

where $f(c/T)$ is a function depending only on the law of action of the forces, and $e^{c/T}$ is the ratio in which the number of impacts is increased by the attractive forces. The equation for internal friction becomes—

$$\eta=\frac{0{\cdot}3503\,.\,\rho\,.\,u}{\sqrt{2}\,.\,N\pi\sigma^2e^{c/T}}$$

One leading result of the mathematical development which follows is that the molecular diameter is set free from dependence on the temperature. A mean value for c (setting hydrogen aside) is 0·58. The results are traced out in various particulars, including the theory of electrons. A. D.

826. *Gaseous Diffusion.* **M. Brillouin.** (International Physical Congress at Paris, Report, 1. pp. 512–530, 1900.)—After pointing out the serious difficulties that attend experiments at other than ordinary temperatures, the author points out that the very act of putting the diffusing gases into communication causes an initial disturbance which can be experimentally demonstrated, and he suggests that this disturbance may be equivalent to a diffusion for some determinable interval. He then discusses Waitz's experiments and Hausmaniger's examination of them, and shows that they really lead to a coefficient of diffusion which, in opposition to O. E. Meyer's view, is in-

dependent of the concentration if the mode of opening communication has advanced the diffusion by a few seconds (15 to 24 in different series) and if distances are measured from a *vena contracta* about 2 mm. away from the actual orifice. He next submits von Obermayer's experiments to criticism, and finds in them, as in Waitz's experiments, no reason for thinking that the coefficient of diffusion of two gases depends on the ratio of the gases in the mixture or on any other circumstance than the uniform temperature and uniform total pressure of the mixture. His final conclusion is that Maxwell's train of reasoning is perfectly rigorous. R. E. B.

827. *Kinetic Theory of Gases and Carnot's Principle.* **G. Lippmann.** (International Physical Congress at Paris, Report, 1. pp. 546–550, 1900. —The author condemns Maxwell's suggested contravention of Carnot's principle by a sorting demon, since an opening to allow the passage of only a single molecule of air must be of molecular dimensions only, *i.e.*, of the dimensions of the intermolecular passages in the walls of the containing vessel, which yet are airtight. Maxwell's contention, nevertheless, that by dealings with molecules the principle may be contravened, is true, and three illustrations of this action are given. The author concludes that the phenomena of heat cannot be explained mechanically; the mechanical theory of heat, indeed, affords an easy interpretation of the principle of equivalence, viz., the existence of a linear relation between a quantity of heat and a quantity of mechanical energy, but it does not necessarily follow that these quantities are of the same nature, even as kinetic and potential energy, which are respectively dependent on, and independent of, time, are not to be confused with each other. R. E. B.

REFERENCES.

828. *Kinetic Theory of Gases.* **Győző Zemplén.** (Ann. d. Physik, 3. 4. pp. 761–763, Dec., 1900.)—A short mathematical discussion in continuation of the points at issue between S. H. Burbury and the author as to the fundamental hypotheses of the kinetic theory of gases. [See Abstracts Nos. 1817 (1900), and 85 (1901).] E. H. B.

829. *Laws of Fluids.* **E. H. Amagat.** (International Physical Congress at Paris, Report, 1. pp. 551–582, 1900.)—The variations of the product pv for a fluid with changes of p and t are exemplified by the author's own curves for CO_2, H_2 and N_2, and a series of general laws regarding the minimum values of pv, the pressure-coefficient $\partial p/\partial t$, the compressibility, isopiestic dilatation, isometric change of pressure, are deduced, the anomalous case of water being separately considered. van der Waals' characteristic and its modifications are then mentioned, and his theory of corresponding states is given in fair detail together with the results deduced later by others. Consideration of the critical state is entirely excluded. R. E. B.

830. *Radiation and Absorption.* **Rayleigh.** (Phil. Mag. 1. pp. 98–100, Jan., 1901.)—Historical. J. B. H.

831. *Solar Calorimeter for Eclipse Observations.* **J. Y. Buchanan.** (Cambridge Phil. Soc., Proc. 11. pp. 37–74, Jan. 30, 1901.)—The paper describes a series of experiments with a steam calorimeter used for determining the amount of solar radiation actually received at the surface of the earth, in distinction to the measurement of the "*solar constant.*" Very minute details are given, describing the geometrical construction of mirrors designed to reflect light along a focal line of given length. C. P. B.

SOUND.

832. *Refraction of Sound by Wind.* **E. H. Barton.** (Phil. Mag. 1. pp. 159–165, Jan., 1901. Paper read before the Physical Society of London.)—The refraction of sound by wind, where the rays are everywhere but slightly inclined to the wind, has been discussed by Rayleigh ("Sound," vol. ii. pp. 132–134), who obtains an approximate expression giving a result which differs only very slightly from the strict value in the numerical illustration used. On the ground of the theoretical interest of the wave propagation in this case, the author now makes a fuller examination of the problem on the basis of Huyghens' principle of wavelets and envelopes. W. C. H.

833. *Production of Beats.* **G. Athanasiades.** (Ann. d. Physik, 3. 4. p. 753, 1900.)—When two open organ-pipes of the same pitch are blown by the same air current, beats may be produced by introducing into the open upper end of one of them a small gas-jet directed vertically downwards. The frequency of the beats, and hence also the difference of pitch, increases with the length to which the gas-jet penetrates downwards. A similar effect may be produced by approaching a gas-flame to the mouth of the organ-pipe. E. E. F.

834. *Apparatus for the Study of Aerial Vibrations.* **F. L. Tufts.** (Amer. Phys. Soc., Bull. 1. pp. 61–62, 1900.)—The aerial disturbances are made to set a stretched membrane in vibration, and its motions are observed in the following way:—To the centre of the membrane is attached a small rectangular piece of tinfoil perpendicularly to its surface, and in this tinfoil a slit is made parallel to the plane of the membrane; a microscope is focussed upon this slit (which is strongly illuminated from the opposite side), and a micrometer in its eyepiece serves to measure the amplitude of vibration of the slit and hence of the membrane.

The apparatus takes two forms, one which is suitable for the measurement of alterations in the density of the air, having its membrane stretched over a globular-shaped resonator; the other, which may be used to measure the amplitude of the vibrations taking place, has its membrane stretched upon a brass ring. The membranes are mounted so that they can be turned about in any direction, and thus the component vibrations in these directions ascertained. The apparatus has been used to verify the law of inverse squares; in the determination of the relative opacity of various substances to sound, and other determinations. W. C. O.

REFERENCES.

835. *Physical and Psychophysiological Effects of Musical Impressions.* **F. Larroque.** (Comptes Rendus, 132. pp. 330–331, Feb. 11, 1901.)—A short note on the author's theories concerning the physiological effects of vibrations. R. S. W.

836. *Architectural Acoustics.* **W. C. Sabine.** (American Architect, 1900, Reprint, pp. 3–68.)—This is the first part of a work dealing with the design of theatres and lecture-halls in accordance with the best acoustic principles. This part deals with the reverberation, with especial reference to the absorbing power of wall-surfaces and of the audience. The author describes a method of measuring this absorbing power by the rate of decay of the original sound, and indicates how to calculate the acoustic properties of a hall beforehand. E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

837. *On the Action Experienced by a Charged Conductor in a Field of Constant Intensity.* **V. A. Julius.** (Archives Néerlandaises, 5. pp. 17–31, 1900.)—A system of conductors is supposed to be placed in a uniform field. Green's integration is applied to the infinite space external to them all. With the usual notation, V denoting potential, dS an element of surface of a conductor, dn an element of the normal measured inwards towards the conductor, x any arbitrary direction, the author finds for a great number of conductors—

$$\Sigma\int\frac{dV}{dx}\frac{dV}{dn}\,dS=0,$$

Σ denoting summation over all the conductors. Similarly—

$$\Sigma\int\left(y\frac{dV}{dz}-z\frac{dV}{dy}\right)\frac{dV}{dn}\,dS=0.$$

He next considers the case of a single sphere placed without charge in the uniform field, of force parallel to x. This may be regarded as a sphere in the interior of which the density is uniform, and equal to ρ, called the positive sphere, coincident with another similar sphere (the negative sphere) within which the uniform density is $-\rho$, and the positive sphere is then displaced through the infinitely small distance dx. By this method the properties of the spherical conductor are deduced. Next is considered the case of a spherical conductor P, with charge hP, and a conductor of any shape Q, with charge hQ, placed at a distance from each other very great compared with the linear dimensions of either. This gives the results—

$$-\frac{k}{4\pi}\int\frac{dV}{dx}\frac{dV}{dn}\,dS=-bh\mathrm{Q},$$

the direction x being that of the field surrounding P. Here k is the dielectric constant, and b the intensity of the field surrounding Q. This shows that the action on Q is reduced to a single force in the direction of the field surrounding Q, equal to the product of the charge and the intensity of the field. The writer finally compares his own results and those of Lorentz's theory (Versuch einer Theorie der electrischen und optischen Erscheinungun Leyden, 1895). According to the theory of this paper, the action on a charged conductor placed in a field of uniform force can be reduced to a force in the direction of the field applied at the centre of inertia of the charge. S. H. B.

838. *Vibration Amplitude of Electrons.* **W. Kaufmann.** (Archives Néerlandaises, 5. pp. 148–151, 1900.)—The author obtains 10^{-8} cm. as a major limit for the amplitude of vibration of an electron, probably much in excess of the true value. He expresses the kinetic energy of the electron, supposed vibrating circularly, in terms of its mass m, amplitude (ρ) and time (τ) of vibration; from Simon's value, $1{,}865.10^7$ (Wied. Ann. 69. p. 611, 1899) of the ratio of the charge of the electron to m, he derives $5{\cdot}19.10^{-4}$ for the value of

the ratio of m to the mass of the hydrogen atom. The energy (K) of the electrons in a gramme-equivalent is therefore $2\pi^2\rho^2 n.5{\cdot}19.10^{-4}/T^2$, n being the number of electrons in an atom. K must be less than the total energy of the gramme-equivalent, and is equal to $\alpha.1{\cdot}26.10^8$ T, where α is less than unity and T is the absolute temperature. Thus ρ is found to be $10^{-8}\sqrt{\alpha/n}$ approximately. W. E. T.

839. *Energy Emitted and Absorbed by a Vibrating Ion.* **M. Planck.** (Archives Néerlandaises, 5. pp. 164–174, 1900.)—The vibrating negatively charged ion or electron is supposed to be the seat of radiation and absorption, absorption causing an increase of its energy of vibration and radiation a diminution of the same. A single negative ion combined with a stationary positive ion to form a molecule is supposed to be situated in vacuo, and owing to the rapid vibration of the negative ion, the molecule constitutes an electric dipole of rapidly changing moment. The expression for the energy emitted by such a dipole is first of all deduced without assuming any particular path for the negative ion, and also an expression for the energy absorbed from an incident train of waves.

These expressions are—

Energy emitted in time $dt = \frac{2}{3}\frac{dt}{V^3}(\ddot{m}_x^2 + \ddot{m}_y^2 + \ddot{m}_z^2)$, where m is the moment of the dipole and V the velocity of light.

Energy absorbed in time $dt = (F_x\dot{m}_x + F_y m_y + F_z m_z)\,dt$ where F_x, F_y, F_z are the components of the electric force of the incident waves at the ion.

These expressions only hold when dt is great compared with the period of vibration.

Assuming the path of the ion to be approximately elliptical, these expressions give us the equations of motion for such an ion. They are—

$$Km_x + L\ddot{m}_x + \frac{2K}{3V^3L}m_x = F_x,$$

and similar equations for y and z, K and L being constants. J. B. H.

840. *Electron Theory of Metals.* **P. Drude.** (Ann. d. Physik, 3. 3. pp. 369–402, Nov., 1900.)—In this second part of his work [see Abstract No. 1276 (1900)], the author deals with the calculation of the electric and thermal transverse effects from data supplied by the electron theory. The theory is best tested by determining for different metals the four transverse effects, as well as the electric and thermal conductivities. When that is done, the mutual electric relations of the metals, more especially the Peltier effect and the thermo-electric force, must result quantitatively. The Thomson effect should also be useful, at all events as regards sign. The reverse process, which consists in determining the thermal conductivity from the four transverse effects and the electric conductivity, is even preferable. The order of magnitude of the Thomson effect in bismuth gives very nearly the same ratio for the conductivity of the positive electrons to the total conductivity as the value obtained from the four transverse effects, being 0·029. A further proof lies in the connection between the Hall effect and the thermo-electric force. When the metals are arranged in the two series there is a well-marked general parallelism, especially at both ends. The middle members do not agree, and cobalt forms a striking exception, standing near antimony in the Hall-effect series, and near bismuth in the thermo-electric series. The author is not

inclined to accept the supposed existence of more than two species of conducting electrons until further experimental material is available. In discussing the optical qualities of gold and copper, the assumption of conducting electrons alone does not seem sufficient, and indeed the author inclines to the assumption of non-conducting electrons in all cases. For if none such existed, his theory would demand the disappearance of the thermo-magnetic transverse temperature effect. The constants of such non-conducting electrons, which are probably fixed in position, can be determined only when the constants of the moving (conducting) electrons are known. Some general conclusions may, however, already be deduced from the optical qualities of metals, and this the author intends to do in the next part of his dissertation. E. E. F.

841. *Motion of an Electrified Particle.* **E. Riecke.** (Phys. Zeitschr. 2. pp. 217–218, Jan. 5, 1901.)—The author has investigated the case where an electrified particle or ion moves in a magnetic field upon which an electric field is superimposed, both fields being uniform. The result of analysis shows that the particle moves along a cycloidal curve. In the diagram, OF is the direction of the electric force, and ON is normal to OF and to the magnetic

force. The projection of the path of the particle upon the plane FON is the curve π. The axis of the cycloid is a parabola, the generating curve is no circle but an ellipse, and the arcs of the cycloid expand during the motion. These results have an important bearing upon the phenomena in the vicinity of the kathode, the changes in luminous layers under magnetic influence, and the theory of the aurora. E. E. F.

842. *Measurement of Atmospheric Electricity.* **F. L. Tufts.** (Amer. Phys. Soc., Bull. 1. pp. 37–39, 1900.)—Experiments were undertaken at Columbia University to study the behaviour of different electrodes in the measurement of atmospheric potential. The electrodes were a flame, a water dropper and a metal point, and were fixed 10 metres from the ground. The potential was measured by the discharge of a condenser of 0·0001 microfarad capacity through a d'Arsonval galvanometer. This condenser assumed the potential of the electrode within one second, and potentials ranging from 5 volts to a few thousand volts could be measured. The potentials assumed by the flame and by the water dropper were usually about the same; that by the point was always much lower. The variations of potential were very rapid; on one occasion a charge from plus 300 volts to minus 280 volts occurred in half a minute. G. H. B.

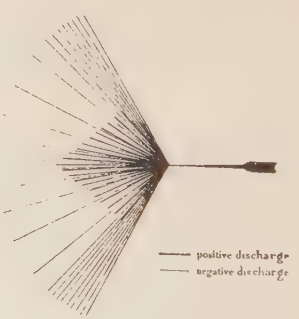
DISCHARGE AND OSCILLATIONS.

843. *Brush-discharge Tones.* **K. Przibram.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 902–904, 1900.)—This is a preliminary note describing experiments made to determine the periodicity of intermittance of brush discharges. According to Beccarias the negative brush-discharge in free air gives a higher tone than the positive. Quantitative experiments are difficult, especially when the medium is changed to various gases. Moreover, since the brush discharge is not of great brilliance, the strobo-photographic method is not easy of application. The author therefore replaces the rotating mirror by a rotating photographic film, and directs the discharge from the electrodes against the films themselves. To determine the velocity of rotation of the film, the light from an arc-lamp is directed upon it through a slit which is closed intermittently at known short intervals by a tuning-fork. After the principal discharge there follows a succession of weaker brushes; these are more pronounced on the kathode than upon the anode, and of greater duration on the kathode. The results for Air and CO_2 are shown in the following table:

	Time between successive discharges.		Total duration of discharges.	
	+	−	+	−
Air	6·8	1·1	33	42
CO_2	3·9	1·3	15	60

The figures when multiplied by 10^{-4} represent seconds. R. A.

844. *Discharge from a Tesla Pole.* **E. Knoblauch.** (Phys. Zeitschr. 2. pp. 165–166, 1900.)—High-frequency currents discharged from a fine point produce in a metallic plate mounted in its neighbourhood a positive charge, but they produce a negative charge when the distance between the point and



the plate exceeds a certain value. This remarkable circumstance is due to the issue of positive brush discharges, which penetrate only to a short distance. The distribution of the two types of discharges is shown in the diagram.

An analogous phenomenon is presented by Lichtenberg's figures.

E. E. F.

845. *Ionisation and Unipolar Discharge.* **J. Stark.** (Ann. d. Physik, 4. 2. pp. 402–415, Feb., 1901.)—A theoretical discussion of ionisation, its causes and limits, stationary ionisation and stationary current, unipolar ionisation, effect of temperature, and unipolar discharge from glowing bodies. For a preliminary paper on the same subject, see Abstract No. 92 (1901.)

D. E. J.

846. *Telephonic Arc-Lamps and Wireless Telegraphy.* **H. T. Simon.** (Phys. Zeitschr. 2. pp. 253–258, Jan. 26, 1901.)—Reference is made to the author's earlier observations [Abstract No. 526 (1898)] on the sound produced by an arc-lamp whose current undergoes periodic variations, and on the inverse influence produced by sound waves, impinging on the arc, upon the strength of the current. On September 8, 1900, the author showed the Physische Verein that the effect could be made extremely loud. Since then he has applied the idea to wireless telegraphy. The telephonic effect is obtained by superposing on a constant direct lighting current, by means of induction, a variable microphone current; and probably the sound is due to variations in the heat produced, and in any case the tendency is to have a greater effect ($\propto i.\,di.\,r.$) the more powerful the main current and the greater the amplitudes of the microphonic current. A Schuckert projection lamp, 16–20 amperes, with differential regulator, was used, and a "1,000-kilom." microphone by Mix and Genest (5 ohms, 2 to 4 volts). A mathematical investigation of the subject is given, from which the most advantageous dimensions and conditions are computed. The wireless arrangement consists of (1) a microphone circuit and a lamp circuit interacting by induction, and a parabolic mirror to produce a parallel beam of light; and (2) a receiving parabolic mirror with a selenium cell at its focus, and a battery and telephone in the circuit of this cell. Reference is made to Duddell's work.

A. D.

847. *Velocity of Ions drawn from a Flame.* **C. D. Child.** (Phys. Rev. 12. pp. 65–83, Feb., 1901.)—Two large parallel tin plates were charged to a known potential difference by means of a water battery; a flame was placed close to one plate and the fall of potential in the space between the plates measured by an electrometer connected to a water dropper. The current, when large, was measured by a galvanometer, and, when small, by noting the rate at which a condenser became charged. When the distance from the flame to the distant plate was 6 cm. and the total p.d. 98·5 volts, the p.d. between the flame and the air space was 7 volts at 1 cm. and 76 volts at 5 cm. from the flame, the corresponding values of the electric intensity (deduced from the curve of fall of potential) being 9·8 and 22 volts per cm., the current density was $0{\cdot}89 \times 10^{-11}$ amperes when the flame was positively charged and the current was carried entirely by positive ions. Substituting these values in the equation given by J. J. Thomson, the velocity of the positive ions is calculated to be 2·08 cm. per sec. for 1 volt per cm.

A simplification of Thomson's method is given in which it is not necessary to measure the fall of potential at points between the plates, but only the current between them; this is based on the supposition that the number of ions in the flame is large compared to the number withdrawn by the current, and that the rate of change of potential in the immediate neighbourhood of the flame is negligible. It leads to the equation $k = 32\pi \times 10^{11} \frac{ib^3}{V_b}$, where k is the velocity, i the current density, b the distance and V_b the p.d. between

the flame and the distant plate. Using this equation it was found that the values for the velocity of both the positive and negative ions decreased as the distance b was increased, and it is suggested that this is due to a gradual decrease in the velocity of the ions after leaving the flame. T. M. L.

848. *Velocities of Ions in the Electric Wind.* **A. P. Chattock, W. E. Walker** and **E. H. Dixon.** (Phil. Mag. 1. pp. 79–98, Jan., 1901.)—This paper forms a continuation of a former one by one of the authors [Abstract No. 104 (1900)], in which the velocities of the ions in the electric wind in air were calculated. The experiments have here been extended to hydrogen, carbon dioxide, oxygen and turpentine. The conclusions are as follows :—

1. The values of V for point-discharge in gases are in approximate agreement with those obtained for the same gases when ionised by Röntgen rays.

2. In non-conducting liquids, V appears to be of the same order of magnitude as in ordinary electrolytes.

3. In hydrogen for negative discharge only, and probably in turpentine for both kinds of discharge, a considerable "back-discharge" of ions seems to occur from the brass or platinum ring towards the point.

4. The amount by which this back-discharge lowers the wind-pressures in the case of hydrogen is closely proportional to the strength of current from the point. This is proved by the constancy of Z_0 in each group of observations.

5. Negative ions in constant fields travel at very varying rates in hydrogen ; the same being true of oxygen and air, but to a much less extent. These variations are real, and not attributable to errors of observation or other accidents. Positive ions are not affected in this respect to anything like the same extent, if at all.

6. To account for this, it is suggested that a certain number of the negative ions may owe their origin to occluded gases in the point ; that this number may be variable owing to changes in the accessibility of the occluded gases and other causes ; and that the specific velocity of the positive ions may be constant owing to their being formed exclusively of the gas outside the point.

A very sensitive manometer was used in the measurements. It consists of an ordinary oil and water differential manometer mounted on a frame, which can be inclined by means of a micrometer screw. Instead of reading the displacement in the narrow tube of the oil-water interface, the interface is kept stationary in the tube by tilting the frame, and the reading of the micrometer screw gives a measure of the pressure. J. B. H.

849. *Leakage of Electricity through Dust-free Air.* **C. T. R. Wilson.** (Cambridge Phil. Soc., Proc. 11. p. 32, Jan. 30, 1901.)—Elster and Geitel [Abstract No. 2023 (1900)] have shown that an electrified body gradually loses its charge when freely exposed in the open air or in a room, and they conclude from their experiments that free ions exist in the atmosphere. In the present experiments the author proves that ionisation can be detected in a small closed vessel containing dust-free air not exposed to any known ionising agents. The rate of leakage is the same in filtered air whether the apparatus be filled and used in the laboratory or in the country ; it is the same for positive as for negative charges, and the same in the dark as in diffuse daylight. To a first approximation the rate of leakage is proportional

to the pressure, being at a pressure of 43 mm. about one-fourteenth of that at atmospheric pressure. Taking the value found by J. J. Thomson for the charge carried by each ion, $6{\cdot}5 \times 10^{-10}$ E.U., the experiments indicate that 20 ions of either sign are produced per second in each c.c. of air at atmospheric pressure. W. C. H.

850. *Rapid Variations in Current through Direct-Current Arcs.* **W. Duddell.** (Inst. Elect. Engin., Journ. 30. pp. 232–267 ; Discussion, pp. 267–283, Feb., 1901.)—This paper is divided into two parts. Part I. deals with effects produced by variations in the current, these variations being generally much less than 10 per cent. of the mean current. When the arc is between solid carbons and the current is suddenly increased, the p.d. and current increase together for less than about $\frac{1}{3000}$th of a second ; at the end of this very short time the p.d. decreases with an increase of current in the ordinary way. If the current through the arc varies by as little as 3 per cent. from the mean, and if the frequency of these superimposed variations is even as high as 4,300 $\sim$ per second, a variation in the light emitted by both the + crater and the vapour column can be detected. A rapid periodic variation of the order of one part in 10,000 from the mean current will alter the vapour column of the arc sufficiently to produce sound waves, as there is probably a definite cross section of the vapour column corresponding to each value of the current. A variation of current of one part in 100 will produce sound waves even at frequencies as high as 30,000 $\sim$ per second. The arc is affected by such small changes of outside conditions as sound waves produce, and can be used both as a telephone transmitter or receiver.

Part II. deals with the variations produced in the current by the arc itself. When the arc hums it rotates and the p.d. current and light emitted vary periodically, the frequency of these variations being the same as that of the rotation of the arc as a whole, and of the pitch of the humming sound. In the hissing arc the p.d., current and light emitted vary very irregularly, the larger and slower variations corresponding with a rotation of the arc as a whole, and the smaller and more rapid to the hissing proper, *i.e.*, the oxygen of the air obtaining access to the crater surface as demonstrated by Mrs. Ayrton. A very short arc, so short that practically no light can get out from between the carbons, sometimes produces a shrill whistling sound accompanied by a small green tongue of flame. This is probably due to the periodical short-circuiting and relighting of the arc, the short-circuit being caused by a bad contact such as a loose piece of carbon. Under certain conditions the direct-current solid carbon arc will emit a musical note when shunted by a self-induction in series with a condenser. When emitting the musical note, the direct-current arc transforms direct-current energy into alternate-current energy, the frequency of the latter being determined by the self-induction, capacity, and effective resistance of the oscillating circuit. The pitch of the note emitted may be used as a means of comparing self-inductions and capacities. If a direct-current arc be shunted with a condenser of several microfarads capacity, the arc will generally be extinguished if the electrodes are of metal, and not if they are of cored carbon, the resistance in series with the arc being non-inductive. If the resistance in series with the arc be highly inductive, then, when the metal arc is extinguished by shunting it with a condenser, a violent rise in p.d. occurs between the terminals of the arc. The rise in p.d. that occurs when an inductive circuit is broken by means of a switch, the contacts of which are shunted by a condenser, is much higher if these

contacts are of metal than if they are of cored carbons, owing to the condenser extinguishing the metal arc formed at the contacts more suddenly than the arc formed when carbon contacts are separated. In an appendix the author mentions that he has obtained a spark of from two and a half to three times the usual length from an induction coil by arranging a contact breaker which applies the condenser to the spark-gap a certain time after the separation of the contacts.

Discussion.—**Ayrton** pointed out that if an arc supplied by accumulators is inserted in any given alternate-current circuit, so that the arc is common to the two circuits, the current in the alternating circuit will be larger than it was before the arc was inserted, other conditions being the same. **O'Gorman** thought cases of damage to concentric cables from the sudden interruptions of the arc between metal contacts of the switch likely to be very rare. **Marchant,** in reference to the introduction of an iron-wire core into the self-induction used to produce the musical arc, pointed out that the eddy current loss in iron wires is many thousand times greater than that in copper, in spite of the relatively great conductivity of the latter. With No. 28 soft iron wires with an induction density of about 15,000 lines per square cm. and frequency 1,000, the eddy current loss is double that due to hysteresis.

E. C. R.

851. *Luminescence and Stratification in Gases carrying Electric Currents.* **J. Stark.** (Phys. Zeitschr. 2. pp. 233–238, Jan. 19, 1901.)—A continuation of previous papers [see Abstracts Nos. 2202, 2203 (1900), and Nos. 98 and 387 (1901)]. The dispersal of kathode rays, ionisation, length of free path, and stratification are discussed with especial reference to the experiments and theories of Goldstein, Lenard, Hittorf, and Thomson. D. E. J.

852. *Striated Discharge.* **E. Riecke.** (Phys. Zeitschr. 2. pp. 227–229, Jan. 12, 1901.)—This paper contains a synopsis of a mathematical investigation of the motion of charged particles in an electric field, with the object of explaining the striæ in the discharge in a Geissler tube. [In this connection see also the papers by J. H. Jeans, Abstract No. 1069 (1900), and by G. W. Walker, Abstract No. 1830 (1900).] The author assumes that the potential of the mutual force between two of these charged ions is only $1/r$ for large values of the distance r, and that for small values of r the potential and its differentials are much greater than according to that law. Assuming the motion of all the particles to be in the direction of the electric force, the force on a particle is given by—

$$X = -P\epsilon(1 - ku^2)\frac{d\eta}{dx} + Qk\epsilon\eta\frac{du^2}{dx} - Rk\epsilon\eta\frac{d^3u^2}{dx^3}$$

where u is the velocity of the particle, η is the volume electric density at the point x, y, z, where the particle is situated, k is the square of the reciprocal of the velocity of light, and P, Q, R are constants which depend on the potential function. For the steady state the current $i = \eta u$. The equation of motion for the particle follows, and assuming the velocity $u = u_0 + u'$ where u' is small compared with u_0 the equation for u' is integrated and the solution is found to be partly periodic. The velocity of the particle thus contains a term which is a periodic function of x. If the particle is supposed to be moving in a frictionless medium the solution is aperiodic. The wave-length of the periodic function is much smaller for the positive ions than for the negative, and herein lies the possibility of solving the problem of the electric double

current in a Geissler tube, at least approximately. Assume that the total quantity of positive charge on ions in the tube is approximately equal to the total negative charge on ions, then, if certain inequalities exist between the controlling constants, a periodic interchange of positive and negative charges must take place in the tube, as observed in the striæ. J. B. H.

853. *Temperatures in Geissler Tubes.* **K. Kerkhof.** (Ann. d. Physik, 4. 2. pp. 327–344, Feb., 1901.)—G. Wiedemann found (by means of a thermo-element applied outside the capillary tube) that in tubes having the same internal diameter, but different external diameters, the discharges of an induction machine produced approximately equal amounts of heat in equal times. The object of the present investigation is to test, by means of the bolometer, the deduction from Wiedemann's law that the temperatures of gases in tubes of different diameters are inversely proportional to the cross sections, the gases examined being carbon dioxide, oxygen, air, and hydrogen. The experiments do not support the conclusion. Wiedemann's law can be brought into harmony with the results of experimental investigation of the actual temperatures of gases in tubes of various cross-sections by assuming that during the discharge heat is given off to the glass and to the surrounding atmosphere. A theoretical discussion shows that when the thickness of the glass wall is constant, the temperature, instead of being proportional to the inverse square of the radius, is at most inversely proportional to the radius; also that, in accordance with the heat conductivities of hydrogen and air, the differences in temperature for different cross-sections should be greater for air than for hydrogen.

In view of the general opinion that the change of the band-spectrum to the line-spectrum produced by using a spark-gap is determined by a rise in temperature, it seemed desirable to examine the changes in temperature produced on inserting a spark-gap. It was found that the insertion of a large spark-gap (2–3 cm.) always gave increased temperatures, and that these increases were more important at low temperatures. The insertion of small spark-gaps lowered the temperature, the probable explanation being that they do not alter the course of the discharge, inasmuch as the Geissler tube requires a higher potential than is necessary for springing across the small gap. Owing to the presence of the latter, however, a part of the energy is lost in the form of heat; thus there is a lowering of the temperature, and this lowering becomes more marked as the length of the spark-gap is increased, and the cross-section of the tube is diminished. But when the length of the spark-gap is so far increased that the difference of potential required to cross it becomes important, then the whole course of the discharge process, as E. Wiedemann has shown, becomes modified; the quantities of electricity which pass through the Geissler tube become greater, and there is a rise of temperature. It may be assumed that when the spark-gap is such as to give the maximum lowering of temperature, the difference of potential required to cross it is the same as that required for the tube; its length must therefore depend upon the pressure.

Schuster and Hemsalech [see Abstract No. 1066 (1900)] found that when a coil of sufficient self-induction was introduced into the spark-circuit, the air-lines disappeared; and this was explained as being due to a lowering of temperature. The author finds that when the discharge takes place in a Geissler tube (instead of between metallic poles in air) the introduction of a special coil causes a rise of temperature at the positive end and a lowering of temperature in the neighbourhood of the kathode. D. E. J.

854. *Hertzian Resonators.* **A. Turpain.** (Archives Néerlandaises, 5. pp. 152–163, 1900.)—By enclosing the wire of a Hertzian resonator in a glass tube along its whole length except at the spark-gap, and exhausting the air from the tube, the condition of the wire with respect to electric pressure is shown by a glow round the wire at the points where the pressure is greatest.

The author has experimented with various modifications of this resonator:—resonators with one or more gaps in different relative positions, resonators with one gap inside the exhausted tube while the other is outside, and resonators with two adjustable gaps.

The experiments lead to the conclusion that the resonator with one gap possesses two nodes, one at each side of the gap, and one ventral segment diametrically opposite to the gap. The pressure at the nodes is greatest when the gap is too great for a spark to pass.

The effect of a small second gap is to reduce the pressure at the two ends of the first gap so long as a spark passes at the second gap, but when the latter is widened so that no spark passes it then resonance ceases. J. B. H.

855. *Coherers.* **C. Jensen.** (Phys. Zeitschr. 2. pp. 211–213, Jan. 5, 1901.)—Röntgen rays often exert an apparent influence upon the resistance of coherers. The author mentions that when he introduced a Röntgen tube into the secondary circuit of an induction coil a Kohl detector for wireless telegraphy showed an immediate response. The response occurred even after taking all kinds of precautions against stray sparks, but it was entirely obviated by enclosing the Röntgen-ray tube in a box with an aluminium window, through which X-rays could freely penetrate. It is therefore clear that X-rays alone do not produce the effect described. The real cause of the effect upon the coherer was, after much investigation, found to lie in the appearance of "gliding sparks" inside the Röntgen tubes themselves. These gliding sparks play about the metallic conductors within the tubes, and appear to glide to and fro along them. That these sparks are the true cause of the phenomenon is made probable by the fact that the appearance or non-appearance of the response depends upon the position of the point at which the sparks appear with respect to the coherer. Preliminary experiments with Becquerel rays show that they have no influence upon coherers.

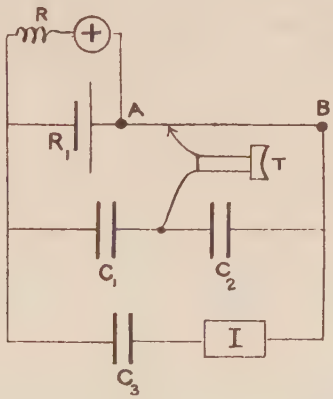
E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

856. *Electrical Resistances of Pure Metals.* **E. van Aubel.** (Archives Néerlandaises, 5. pp. 49–55, 1900.)—This paper is an examination of Dewar and Fleming's determination of the electrical resistances of tin, cadmium, and nickel at different temperatures. The resistance of tin in microhms per cub. centimetre was found in 1892 to be 9·609 at 0·8° C., while in 1893 it was 13·100 at 1·0° C., the tin wire being prepared differently in the two cases. The resistance of cadmium was found to be 10·023, with a temperature coefficient between 0° and 100° C. of 0·00419. Benoit, however, found a resistance of 6·85, with a temperature coefficient of 0·00444. For nickel, prepared from nickel-carbonyl, Dewar and Fleming found in 1892 and 1893 resistances of 12·350 and 12·402 at 1·2 C., the temperature coefficients, however, varied from 0·0049 to 0·0298; in 1900 Fleming found for nickel prepared electrolytically, a resistance of 6·935 at 0° C. with a temperature coefficient varying from 0·0058 to 0·2074. The author considers these results so divergent as to render doubtful Dewar and Fleming's conclusions, that the resistance of pure metals

vanishes at absolute zero of temperature. He also considers it unadvisable o make measurements extending over a large range of temperature on other han straight wires. G. H. B.

857. *Resistance of Lead Accumulators.* **F. Dolezalek** and **R. Gahl.** Zeitschr. Elektrochem. 7. pp. 429–433, Jan. 24 ; and 437–441, Jan. 31, 1901.)—After a description of some previous observations, the authors describe a method for the measurement of cell resistance. It is essentially a Kohlrausch alternating current and telephone method, but involving the use of condensers. The diagram shows the arrangement of the apparatus. An induction coil, I, with fine wire primary connected to the 110-volt circuit has in its secondary circuit an aluminium cell, C_3, which acts as a condenser. Two other condensers, C_1 and C_2, each made of 50 sheets of tin foil, 4 square decimetres in area, insulated with paraffin paper and mounted between boards that may be pressed together with a wooden screw, are used. The bridge, AB, is of 3 mm. thick rheotan wire of 1 m. length. At the ends A and B are mercury cups.



A telephone, T, with short, thick windings, is arranged as shown with a contact variable along the bridge wire. The cell, R_1, is discharged through glow-lamps, R, and has in its circuit an ammeter. It is also provided with a voltmeter (not shown) at its terminals. The wire, AB, is calibrated by using known resistances placed at R_1 instead of the cell. With this apparatus many measurements have been made, and the results are given in the form of curves showing the dependence of the resistance on the state of charge. Measurements have also been made to separate the resistance of the positive plate from the negative plate by using an auxiliary electrode of lead peroxide. These show that the variation of the resistance of the positive plate is relatively of small importance. The influence of the charges of concentration of the electrolyte, due to diffusion when the cell is not in use, are discussed. W. W. H. G.

858. *Electric Convection.* **V. Crémieu.** (Soc. Franç. Phys., Bull. 156. pp. 2–3, 1901.)—The reciprocal of the Rowland effect would be an inductive ponderomotive force acting on a body bearing a charge and placed near an electromagnetic solenoid in which there was a variation of flux $d\phi/dt$. Crémieu has been unable to find any such effect. He has also tried the Rowland phenomenon with more powerful apparatus, and concludes that

there is no magnetic effect of convection, but that there are some deviations due to a phenomenon of conduction in the fixed sectors of his rotating apparatus. [See also Abstract No. 144 (1901).] A. D.

859. *Oil in Mica.* **T. O. Moloney.** (Elect. Rev. N.Y. 38. p. 107, Jan. 19, 1901.)—The puncture resistance of mica was found to be reduced by one-half its value by lightly coating the surface with paraffin oil. M. O'G.

860. *Dielectric Cohesion in Gases.* **E. Bouty.** (Soc. Franç. Phys., Bull. 158. pp. 5–6 ; Discussion, pp. 6–7, 1901.)—A gas, within glass, in an electrostatic field acts as a perfect dielectric up to a certain critical value of the field. Thereafter it yields and acts as if it were a metal. Dry steam is a perfect insulator. The critical value of the field is, for pressures above a few mm. of mercury, a linear function of the pressure : at progressively smaller pressures it passes through a minimum and then increases, nearly inversely as the square of the pressure, down to about $\frac{1}{50}$ mm. The strength of field requisite for sparking is also a linear function of the pressure, together with a term which depends on the electrodes themselves and the glass. A. D.

861. *Variation of Dielectric Constant under Stress.* **G. Ercolini.** (N. Cimento, 12. pp. 77–90, 1900.)—The author replies to the criticism of Corbino [Abstract No. 134 (1900)] and maintains that he has clearly established an increase of the dielectric constant of glass under the influence of tension. He admits, however, that he has not determined its order of magnitude. E. E. F.

862. *Conductivity of Gases when Carrying Electric Discharges.* **J. Stark.** (Ann. d. Physik, 4. 1. pp. 215–224, Jan., 1901.)—In general the conductivity of a gas carrying an electric discharge cannot be determined by the usual methods on account of the occurrence of internal electromotive forces [see Abstract No. 387 (1901)]. The unstratified positive layer is an exception. In it the transverse conductivity is for a considerable distance constant ; the gas is in an uniform state and exhibits no internal electromotive forces. The specific conductivity is $\lambda = i.l/q.e$, where i is the current and e the potential difference between two layers of cross-section q and at a distance l apart. The author calculates its values for pressures of 1–7 mm. from the observations of A. Herz (Wied. Ann. 54. p. 254, 1895). The results obtained are as follows : I. *Variation of Current.*—For small current-densities the conductivity is proportional to the current-density ; for larger current-densities the conductivity increases more rapidly than the current. II. *Variation of the Cross-Section.*—The effect of current-density on conductivity is also shown by varying the cross-section while the current remains constant : in this case also the conductivity increases with the current-density. But for equal current-densities the conductivity is smaller for small cross-sections than for large ones. III. *Effect of Pressure on Conductivity.*—The conductivity increases rapidly when the pressure diminishes.

The author takes as normal or mean value of the variables concerned a current of 1 milliampere, a pressure of 4 mm., and a cross-section of 2 sq. cm., and for these values gives the conductivity of nitrogen as $11{\cdot}28 \times 10^{-6}$ and of hydrogen as $17{\cdot}29 \times 10^{-6}$. D. E. J.

863. *Thermo-electric Behaviour of Metallic Oxides and Sulphides.* **E. van Aubel.** (Ann. d. Physik, 4. 2. pp. 416–419, Feb., 1901.)—A. Abt [see Abstract

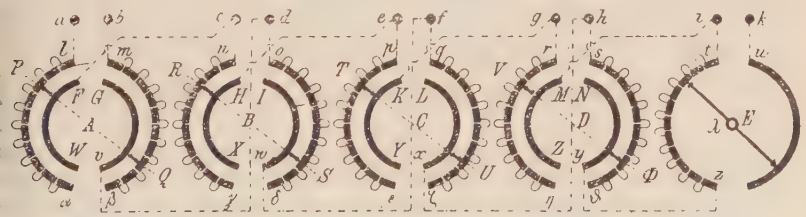
No. 1680 (1900)] has investigated the thermo-electric behaviour of certain metallic compounds. He places them in a series beginning with chalcopyrite (negative) and ending with pyrite (positive), and states that the members of this series follow approximately the laws which represent the behaviour of the corresponding thermo-electric series of metals. Thus, for example—

Pyrolusite | Carbon + Carbon | Pyrite = Pyrolusite | Pyrite
315·2 + 615·6 = 930·8 (933·2 observed).

The author has tested the accuracy of this statement by examining and comparing other data given by Abt, and finds that it is not justified. D. E. J.

864. *Conductivity for Heat and Electricity, Heat-Capacity, and Thermoelectric Power of Certain Metals.* **W. Jaeger** and **H. Diesselhorst.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 269–424, 1900.)—This is the complete memoir corresponding to Abstract No. 137 (1900). It contains elaborate mathematical discussions of the sources of error, and gives full details of the precautions that must be taken in the experiments, and of the corrections that must be applied in the calculations. The numbers given in the former paper have been revised, the chief alterations being in augmentation of the values of λ/κ at 100° C. with slight diminution of the values of κ at 100° C.; the results for manganin (84Cu, 12Mn, 4Ni) are also now given. R. E. B.

865. *New Form of Slide-Wire.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. p. 1067, Dec. 20, 1900.)—The arrangement will be easily understood from the accompanying sketch. The "wire" consists of a series of coils connected to circular contact-blocks over which a contact-arm may be made to move. Each of the eighteen coils in the set A has a resistance of 1,000 ohms; in B, 100; C, 10; and D, 1 ohm. The 10 coils at E have each



a resistance 0·1 ohm. The contact-arms which move over A, B, C, and D are each furnished with two diametrically opposite contacts insulated from each other, while the arm at E is a metallic arm bridging across the semicircular series of contacts on the left and the semicircular contact-ring on the right: *a* and *b* correspond to the ends of the "slide-wire," while *k* is the point of division. A. H.

866. *Errors in Magnetic Measurements due to Skin of Oxide.* **H. Kamps.** (Elektrotechn. Zeitschr. 22. pp. 75–79, Jan. 24, 1901.)—On account of the skin of oxide which forms on the surface of iron stampings, the actual cross-section of iron is somewhat uncertain. The present paper contains an account of experiments undertaken with a view to determining the amount of error incurred in magnetic measurements due to this cause. The author determined the apparent induction on the supposition that the entire cross-section

consisted of iron, and then found the true induction by dissolving off the skin of oxide. The results indicate that the apparent differs from the true induction by an amount ranging from 6·7 per cent. in the case of stampings 0·75 mm. thick to 13 per cent. for stampings 0·375 mm. thick. The thickness of the double skin of oxide deduced from these measurements is about 0·05 mm. The author further discusses the errors introduced into measurements of the hysteresis loss when (*a*) the field intensity and (*b*) the induction is the same in two samples with and without a skin of oxide respectively.

A. H.

867. *Mercury Standard for the Ohm.* **W. Jaeger** and **K. Kahle.** (Zeitschr. Instrumentenk. 21. pp. 1–10, Jan., 1901. From the Phys. Tech. Reichsanstalt, Wiss. Abh. 3. p. 95–153, 1900.)—In a former paper (Zeitschr. Instrumentenk. 16. p. 134, 1896) an account is given of the formation of two mercury columns for the standard of resistance in the Reichsanstalt. It was thought advisable to use a larger number of mercury columns in the Definition of the practical unit of resistance and three others were accordingly made. The present paper describes the standardising of these three. One had a section of about 0·5 sq. mm. and a resistance of about 2 ohms; the second a section of 1·3 sq. mm. and 0·5 ohms resistance; and the third, like the old ones, a resistance of about 1 ohm and a section of 0·75 sq. mm. The results are given in the following table:—

Number of Tube.	No. 106.	No. 114.	No. 131.
Length at 0°	654·954 mm.	810·947 mm.	1009·627 mm.
Hg-contents at 0° ...	11·20122 gm.	8·43914 gm.	6·60451 gm.
Sectional area (about)	1·258 mm².	0·766 mm².	0·481 mm².
Calibration factor ...	1·000169	1·000021	1·000168
Resistance at 0°	0·4898850 int. ohms	0·996692 int. ohms	1·974328 int. ohms
Terminal resistance	0·0007579 „ „	0·000972 „ „	0·001219 „ „
Total resistance at 0°	$\begin{cases} 0{\cdot}490642_9 & „ \quad „ \\ 0{\cdot}492031_5 \text{ leg.} & „ \end{cases}$	$\begin{cases} 0{\cdot}997664 & „ \quad „ \\ 1{\cdot}000488 \text{ leg.} & „ \end{cases}$	$\begin{cases} 1{\cdot}975547 & „ \quad „ \\ 1{\cdot}981139 \text{ leg.} & „ \end{cases}$

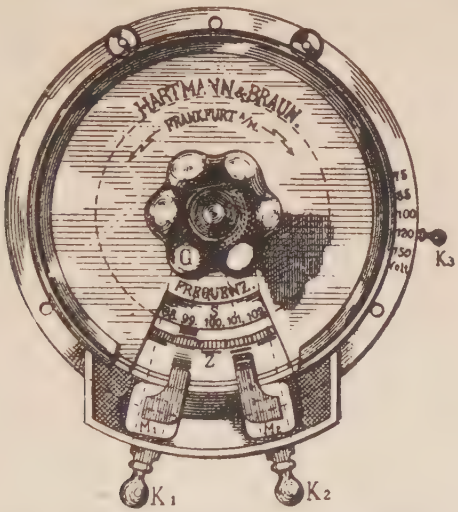
J. B. H.

868. *Periodic Curve Tracer.* **R. Franke.** (Zeitschr. Instrumentenk. 21. pp. 11–20, Jan., 1901.)—The instrument here described is similar to that formerly described by the same author [see Abstract No. 186 (1900)]. The alterations introduced here consist only of improvements in the mechanical details and in the arrangement of the parts to ensure that the axis of rotation of the brushes shall coincide with the axis of rotation of the commutator. For this purpose the brush-holder is mounted on a ball-bearing on the commutator itself instead of on the framework, and it is kept from rotating by a projecting arm carried by the frame, which can be slowly rotated by hand so as to make the brushes close the circuit at all the different phases of the alternating current.

J. B. H.

869. *Measurement of Frequency.* **R. Kempf-Hartmann.** (Elektrotechn. Zeitschr. 22; pp. 9–15, Jan. 3, 1901.)—After briefly reviewing the various methods which have from time to time been used for frequency measurements, the author explains the main principle underlying the construction of his own instruments. This consists essentially in using a series of steel

tongues capable of vibration when excited by an electromagnet traversed by the alternating current. The amplitude of vibration is very considerable, so that the vibration is clearly visible. The construction of this type of instrument will be readily understood by reference to the accompanying figure. Rigidly clamped to the periphery of a movable circular frame is a set of steel tongues, the vibration frequencies of which range from 79 to 110. Any one of these tongues may, by means of the milled head G, be brought within the range of action of an electromagnet which is excited by the alternating current. This electromagnet consists of two parts, M_1 and M_2, which may be displaced relatively to each other by means of the handles K_1 and K_2. When it is desired merely to determine the frequency, M_1 and M_2 are brought together, and the compound pole-piece thus formed is of sufficient width to



act simultaneously on two neighbouring tongues. The milled head G is then turned until a pair of tongues is reached whose vibration amplitudes exceed those of any other pair. By comparing the relative amplitudes of the strongly vibrating tongues, fractions of a period may be estimated. If it is now desired to study fluctuations of frequency, the component parts M_1 and M_2 of the magnet are separated, and the sound ceases. But if the frequency either falls to that corresponding to the tongue opposite M_1, or rises to that corresponding to the tongue opposite M_2, the observer is immediately warned of this fact by the note emitted by the corresponding tongue. The concluding portion of the paper describes the application of this principle to the determination of the slip of induction motors. A. H.

870. *Wehnelt Interrupter.* **A. Lampa.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 891–901, 1900.)—The Wehnelt interrupter is less efficient when the smaller electrode is negative than when it is positive. Simon attributes this to a secondary action resulting from the occlusion of hydrogen by the platinum. Wehnelt and Spiesz thought it might be due to the difference in the character of the sparks corresponding to the two directions of the current. The author investigates the question by experiments made with a coherer circuit containing a galvanometer. The apparatus is not described, but it

appears that the coherer is used as a quantitative detector for the waves, the throw of the galvanometer being assumed proportional to the intensity, or some other quality, of the spark. The result arrived at is that the effect upon the coherer under continued sparking at the interrupter is very pronounced when the smaller electrode is negative, but that the effect is very small when the smaller electrode is positive. The length of the smaller electrode was next varied by increments from 13·2 mm. to 0·1 mm. So far as these observations go, it appears that the effect on the coherer is the same for both these lengths, but that it is greater for lengths between those values. As against the occlusion theory, the following table shows the galvanometer throws corresponding to the electrodes of different metals :—

		Pt	Cu	Ir	Fe	Ag	Pd	Au	Al
Deflections when the small electrode is	positive	6	2	6	2	5	5	1	5
	negative	20	16	26	20	18	18	12	19

From these experiments the author concludes that the difference produced by commutation does not depend simply upon the nature of the metal of the small electrode. The waves received by the coherer proceed of course from the whole circuit containing the interrupter. The effect produced at the coherer is, apparently, greatest when the interrupter is working quietly, and least when the interrupter is working violently. Using a Geissler tube in place of the coherer as a detector, arranged as in the experiments of Borgmann and Petrowski, it was found that the effect upon the tube is greatest when the small electrode is positive. Further tests are described in which a mercury contact key, with a platinum plunger, replaces the Wehnelt interrupter. The effect upon the coherer circuit in this case is the same whether the mercury is covered with water or alcohol, or is left uncovered, and it is independent of the direction of the current through the mercury contact. If, however, the mercury is covered with dilute acid, the effect upon the coherer is very much increased if the plunger is negative, and weaker if the plunger is positive. There are occasional impulses of intensity much greater than the normal ; this can be shown even when using an ordinary tapper key. The author investigates the phenomenon, and shows it to be a resonance effect, depending upon the resistance, self-induction, and electrolytic capacity of the circuit at the moment of interruption. It is to be noted also that the resistance is smaller when the small electrode is positive, than when it is negative. The spectrum proves both hydrogen and platinum to be present when the small electrode is negative ; but only hydrogen when the small electrode is positive. A rotating mirror shows that the spark is of shorter duration when the small electrode is positive than when it is negative ; in the latter case the appearance is of a discontinuous band of light of silvery brightness. R. A.

871. *Wehnelt Interrupter.* **Meller.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 179–214, 1900.)—The author shows that by supposing $\frac{di}{dt}$ to vary according to a sinusoidal law, it is possible to explain all the phenomena of interrupted circuits, including those produced by the Wehnelt and Moor interrupters. The interruption must be considered not as the introduction of an infinite resistance but as the introduction of a capacity. Although this gives only a rough approximation to actual occurrences, it introduces no essential error. E. E. F.

872. *Siemens and Halske's Rail-bond Tester.* **J. A. Montpellier.** (Électricien, 21. pp. 105–107, Feb. 16, 1901.)—This apparatus comprises a pair of contacts *a*, *b*, adjustably mounted on a graduated bar of insulating material which is provided with a handle, and a third contact *c* which is mounted on a separate handle. A differential galvanometer is also provided of the Deprez-d'Arsonval type, in which the two coils on the movable frame are suspended between two thin strips of bronze stretched by spiral springs. The apparatus is used as follows :—The two terminals on the bar are placed on the rails, one on each side of the joint, and the separate terminal on one side thereof along one of the sections of the rails, the centre contact *b* being connected to the common terminal of the galvanometer coils and the outer contacts *a*, *c* to the separate ends of the coils. The movable contact *c* is then adjusted until the pointer stands at zero. If l = the distance along the undivided rail between the contacts *b c* ; l' = the distance across the joint between the contacts *a b* ; and p = weight per metre of the rail in kilos, the resistance of the joint is—

$$0.25 \times \frac{l - l'}{p} \times 10^{-3} \text{ ohms.}$$

C. K. F.

ALTERNATING CURRENTS AND MAGNETISM.

873. *Sinusoidal Currents.* **M. Wien.** (Phys. Zeitschr. 2. pp. 245–247 ; Discussion, p. 247, Jan. 19, 1901. Paper read before the 72nd Naturforscher-versammlung at Aachen.)—The ideal would be continuous and uniform sinusoidally oscillating currents of any frequency, say from 1 to 10^{12} per second. Alternating currents, to be now described, do not attain this character till their frequency is at least over 17,000 ; and we can scarcely go beyond 50,000, but then, on the other hand, they are nearly sinusoidal, the higher components being reduced to about 1 per cent. of the fundamental. These currents are obtained by a multipolar arrangement analogous to a siren ; masses of iron brought successively between the poles of an electro-magnet wound with copper wire, in the circuit of which there is a condenser and an inductor. The amplitude of the current then is—

$$E \div \sqrt{\{R^2 + (nL - n^{-1}C^{-1})^2\}} ;$$

and when $n^2 = (CL)^{-1}$, the current is a maximum. But it is only a maximum for the fundamental oscillation ; the higher components are left relatively feeble. Incidentally a resonance galvanometer was described which only responds to oscillations of a particular frequency. In Ann. d. Physik, 4. 3. pp. 425–449, March, 1901, the author further develops the subject. A. D.

874. *Magnetic Properties of Matter.* **H. du Bois.** (International Physical Congress at Paris, Report, 2. pp. 460–508, 1900.)—This is a summary of our present knowledge of the susceptibility of materials, solid, liquid, and gaseous, whether simple or compound, including organic bodies ; much attention is given to variation in susceptibility with change of temperature and of magnetic field. There are three main divisions to the paper :—

I. *Ferromagnetics.*—These substances are characterised by high, variable susceptibility, and by hysteresis. The members are iron, nickel, cobalt, manganese, at temperatures below the transformation-point. (Above this point, which is 750° for iron, they must be placed among paramagnetics). Iron, its amalgams and alloys with antimony, aluminium, &c., also its oxides

and sulphides are fully treated, the range of temperature being in some cases from -200° C. to $+1{,}400^{\circ}$ C. Some mention is also made of other members of the group.

II. *Paramagnetics.*—In this division the substances have positive but small susceptibility and no hysteresis.

The members are several metallic groups, *e.g.*, the platinum and aluminium groups, the ferromagnetics above the transformation-point, a great number of salts, also oxygen and ozone.

It is impossible yet to say that paramagnetic substances in solution are strictly insensible to changes in field, but the evidence points that way. P. Curie has found a principle, which the author considers of great importance, and calls *the Law of Curie.*

Let $\begin{cases} S = \text{specific magnetisation,} \\ \chi = \quad ,, \quad \text{susceptibility,} \end{cases}$

$$\therefore S = \frac{\text{magnetic moment}}{\text{mass}} = \frac{\text{magnetic intensity}}{\text{density}};$$

then—

$$\chi = \frac{S}{H},$$

and Curie's Law states that—

$$\chi\theta = C,$$

where θ is the absolute temperature,
and C is a constant (Curie's constant) depending on the substance.
As an example, $FeSO_4$ solution gives—

θ	285°	319°	381°
$C = \chi\theta$	0·0245	0·0241	0·0241

It will be observed that the law of Curie states that the specific susceptibility varies inversely as the absolute temperature, *i.e.*, inversely as the kinetic energy of thermic movements. A remarkable table is also given, showing how the members of any group of salts are related together by means of Curie's constant.

III. *Diamagnetics.*—These bodies have susceptibility negative and independent of the field, also no hysteresis. The list includes bismuth, phosphorus, antimony, water, and many gases.

One general characteristic of all the bodies is that susceptibility diminishes as temperature rises, but much less than for paramagnetics. Often the change is inappreciable; hence for these the law of Curie does not hold. Water, a most important case, is fully dealt with. P. E. S.

875. *Magneto-kinetic Top.* **H. du Bois.** (Archives Néerlandaises, 5. pp. 242–251, 1900.)—Several writers have on theoretical grounds doubted the existence of diamagnetism, and Siertsema has shown that starting from Maxwell's theory, negative magnetism is an absurdity. But, on the other hand, diamagnetic facts can be experimentally shown without any doubt. The author, therefore, has devised the above instrument to illustrate para- and dia-magnetic phenomena, the top being the analogue of the ultimate magnetic particle, which he calls the *magnecule.* Imagine a permanent steel magnet placed in a magnetic field and capable of turning round an axis, which can form with the magnetic axis and with the field any angle whatever. Such a state of things can be realised by mounting the magnet in a complex

gyrostat—the magnetic field being produced by coaxial bobbins which can be set at any inclination to the horizon. Suppose that the axis of rotation is vertical and the magnetic axis also vertical; then when the top is set spinning, the magnet will tend to set horizontally, where there is kinetic stability. Remembering this, we have two cases :—

I. *When the axis coincides with the field.* The field tends to bring the magnet to point along it, but if there is any spin at all, it will require an infinite field to make it reach that limit. Also supposing the spin to be considerable, it is evident that the movement of the magnet will be small and independent of the strength of field, at any rate for small fields, but the movement will be inversely as the kinetic energy of the rotation. Thus the magnetic moment of the magnet (1) will have a *positive* increment; (2) will be independent of the field, at first; (3) will vary inversely as the kinetic energy of rotation, but this implies that for the magnecule, susceptibility will vary inversely as the absolute temperature. The first two conditions are well known for *paramagnetic* bodies, and the third condition is in accordance with the Law of Curie [see preceding Abstract] for them.

II. *When the axis is perpendicular to the field.* The magnet will now remain always in a horizontal plane (as it was before the field was put on); but as the magnet rotates, its magnetic moment will have a positive current when the + pole points to the N., and a negative increment when the — pole points to the N. When the field is intense, there will be a retardation in the rotation when the magnet moves through 180°, followed by an acceleration in rotation through the next 180°. On integrating round a complete turn the increment in magnetic moment will be found to be *negative*. Thus in this case (1) the susceptibility is negative; (2) for small fields it is independent of the field; (3) the susceptibility varies inversely as the kinetic energy of rotation. Here, then, we have the analogue of *diamagnetism*.

There are other applications of the top, *e.g.*, the Earth. This has a magnetic axis inclined at about 20° to its axis of rotation. What would be the influence of a solar or cosmic field on the Earth's motion?

The most modern conception of the magnecules supposes that the Ampere currents are really the convection currents of the charged ions as satellites revolving round the atoms as their planet. It will be seen that the magneto-kinetic top is in no way at variance with that conception. P. E. S.

876. *Physical Modifications due to Magnetisation.* **Hurmuzescu.** (International Physical Congress at Paris, Report, 2. pp. 557–567, 1900.)—From very many experiments it can be shown that the state of magnetisation has some connection (unknown to us) with the structure of the body magnetised. Thanks to Maxwell's theory the existence of tensions has become familiar to us—but when these principles are put to the test the results of different experimenters are at variance with one another. The author divides his remarks into two groups.

I. *Diverse Modifications.* (*a*) If magnetisation is accompanied *simply* by orientation of particles, then in a homogeneous, isotropic body there should be no change in volume on magnetisation. It can be shown on general reasoning that—

$$dW = MdI - pdv,$$

where dW is the total variation of internal energy, M is a function of the field, and p and v are the pressure in, and volume of, the body; hence, by further reasoning, it can be shown that when the field increases the volume

of the body should decrease. The author has examined several solutions of iron salts and finds a decrease as anticipated. Hence the simple orientation theory is insufficient. (*b*) The resistivity of iron and nickel increases and that of bismuth decreases on account of magnetisation, but the resistivity of solutions of salts of iron seems to be unaffected. (*c*) The author has not been able to perceive any influence by magnetisation on the transport of ions.

II. *Electromotive Forces due to Magnetisation.* If a magnetised iron rod and an unmagnetised one be placed in some acid which attacks them, it will be found that on completing a circuit a current will flow in the sense that the magnetised rod acts as the positive pole of the cell; *i.e.*, the current leaves the cell by it. In investigating this point the author uses a capillary electrometer to measure e.m.f., and takes special care to eliminate polarisation by having very small contact areas. We have the following form of energy in the system :—(1) Magnetic energy in each of the two poles, and in each of the adjoining liquids ; (2) mechanical energy due to tension in the metal ; (3) electric energy due to the potentials of each of the two poles and of each adjoining liquid ; (4) any other form of energy, *e.g.*, heat energy. Thus an energy equation can be formed ; and it can be reduced by various suppositions to the simple form—

$$E = \frac{l}{\delta} \cdot \frac{I^2}{2k},$$

where E = e.m.f., l = electro-chemical equivalent, δ = density of the solid I and k are intensity and susceptibility.

In his investigations the author found that iron (when H = 2,000 c.g.s.) has E = 0·01 volt, whilst nickel, for the same field, has E = 0·001 volt, and bismuth has E = 0·0001 volt, and in the opposite sense to iron and nickel ; these numbers express the *order* of the effect.

It is important to notice that in the above experiments the surface touching the liquid is *not* made a magnetic pole ; if, on the other hand, we dispose the electrode so that the surface of contact *is* a pole, then the e.m.f. is much smaller and is sometimes positive, sometimes negative, according to the nature of the liquid. To sum up, we notice that (1) magnetic bodies become by magnetisation less susceptible to attack by acids than when unmagnetised ; (2) the neutral pole is carried (in ions) to the magnetised pole ; (3) in bismuth, and other diamagnetics, these properties are reversed. P. E. S.

877. *Unipolar Induction.* **E. Hagenbach-Bischoff.** (Archives des Sciences, 11. pp. 5–47, Jan., and 142–160, Feb., 1901.)—Lecher having lately published a paper [Abstract No. 94 (1900)] on the rotation of a magnet when traversed by a current, in which he condemns the generally accepted explanation of this phenomenon, the author has conducted a series of experiments with the view of showing that the action between a current and a magnetic pole is fully accounted for by Biot-Savart's law.

A round-bar magnet is pivoted vertically in mercury cups so as to be capable of rotation about its axis ; if the magnet be rotated through a pulley, the e.m.f. induced can be measured between either mercury cup and the centre of the magnet, or, if a current be passed through the magnet at these points, the turning moment produced can be measured by the angle through which the magnet turns when suspended by a bifilar suspension. Starting from Biot-Savart's law, the author deduces that

$$D = -e = -2\mu,$$

where D is the moment of the couple produced by unit current passing

through the magnet, e is the e.m.f. produced by unit angular velocity, and μ is the strength of the magnet pole. The value calculated for D and $-e$, from the dimensions and strength of the magnet, is 296, while that found by experiment is 322 for D and 320 for e. As in his calculations the author had assumed the magnetism to be concentrated at points in the bar distant five-sixths of the length of the magnet, he considers the agreement between theory and experiment sufficiently close to prove the applicability of the Biot-Savart law. If the e.m.f. be measured at some point on the magnet other than the centre, it is found to be smaller the nearer the point is to the pole. Similar experiments are made with a magnet provided with a circular mercury trough of insulating material fixed to it at the centre of its length; connection between the mercury and the magnet is made at various points of the latter by copper wires of various shapes, the terminals for introducing the current or for measuring the e.m.f. being the mercury trough and one of the mercury cups. The author gives the calculations for various forms of circuits in detail, and finds the results in every case confirmed by experiment. The author next experimented with an arrangement similar to Lecher's, consisting of two rod magnets mounted parallel to, and one on each side of, the vertical axis; currents could be introduced at either of the mercury cup pivots or at an annular mercury trough, and could be passed through the axis, or through one or both of the magnets. In these experiments, also, the experimental results are in close agreement with those calculated from theory. In every case it is only in the parts of the circuit parallel to the magnets that the current has any influence on the rotation. In the second part of the paper the author describes König's apparatus, which consists of a number of U-shaped magnets, arranged in radial planes, with all S poles at the centre and all N poles on the circumference of a circle; a metal cylinder, embracing the central poles, is capable of rotation about a vertical axis. When a current passes along the cylinder, the author deduces the moment between the cylinder and the bundle of magnets to be $2i\Sigma\mu$, where i is the current and μ the pole-strength of each magnet. This is in complete agreement with Fleischmann and König's experiments. The author finally devotes fifteen pages to a discussion of Biot-Savart's law, and Ampère and Grassmann's formulæ, and concludes as follows: Referring to the arrangement where a single vertical magnet has fixed to it an annular mercury trough, the current passing from the upper mercury cup to the middle of the magnet, and thence along a horizontal wire to the mercury trough; the rotation of the magnet may be explained, according to Biot-Savart's or Grassman's laws, by internal forces only, the external portion of the circuit from the mercury trough to infinity being inactive; on the other hand, when explained according to Ampère's formula, the internal forces counteract one another, and the effect is due to the external forces produced by the portion of the circuit from the mercury trough to infinity. G. H. B.

878. *Unipolar Induction.* **E. Lecher.** (Ann. d. Physik, 3. 3. pp. 513-521, 1900.)—The author examines the significance of Pohl's experiments both from Faraday's and König's point of view, and shows that the old Biot-Savart rule of the rotation of a "pole" about a linear conductor, without taking the remainder of the circuit into account, leads to conclusions which are contradicted by experiment. The usual explanation of Pohl's rotation as a motion of a pole along the circular lines of force surrounding a conductor cannot be maintained. The rotation is due to the remainder of the circuit, which hitherto was left out of account. [See further Abstract No. 877 (1901).] *E. E. F.*

879. *Magnetostriction.* **H. Nagaoka.** (International Physical Congress at Paris, Report, 2. pp. 536–556, 1900.)—*Magnetostriction* implies the volume change of a substance when magnetised. A considerable amount of the work in this report will be found in Phil. Mag., vol. xlvi. [see Abstracts Nos. 714 (1899) and 1097 (1900)]. But the whole subject is in this instance treated more fully and widely. Much of the discussion turns on the expressions derived by Cantone from Kirchhoff's principles, viz.—

$$\frac{\delta l}{l} = \left(\frac{4\pi k^2}{3}\,\frac{1+\theta}{1+2\theta} + \frac{k-k'}{2(1+2\theta)} - \frac{k''}{2}\right)\frac{H^2}{E},$$

$$\frac{\delta v}{v} = \left(\pi k^2 + 3\,\frac{(k-k')}{4} - \frac{k''}{4}\right)\frac{H^2}{K(1+3\theta)},$$

where l and v are the length and volume of the specimen ; H is the magnetic field ; E and K are Young's Modulus and Rigidity ; θ is given by the expression, $\frac{E}{2}\frac{1+2\theta}{1+3\theta} = K$; k, k', k'', are constants depending on the substance. A considerable amount of information has been accumulated on the relation to one another of the following variables :—(1) Longitudinal field, (2) circular field, (3) longitudinal stress, (4) torsional stress, (5) change in length of the substance, (6) change in volume of the substance.

Since we may observe the variation of one of these when one or more of the others vary, it is obvious that for complete investigation of the whole series a great amount of work would be required. All the known data are tabulated in this report, but the author considers that it is principally for the interior of the magnet that difficulties arise. To the difficulties of theoretical interpretation of the subject are added the difficulties of experimental verification. We require accurate knowledge of (1) elastic constants, (2) permeability and other magnetic factors, (3) deformation of the substance, (4) the strains set up in the substance. The subject is still in its infancy, and there is scope for abundant future investigation. P. E. S.

880. *Torsional Magnetostriction in Strong Transverse Fields.* **C. Barus.** (Amer. Journ. Sci. 10. pp. 407–418, Dec., 1900.)—The author discusses his experiments on this subject and illustrates the phenomena by means of a mechanical model. The results of the experiments indicate that the effect of longitudinal magnetisation is an increment of rigidity in all paramagnetic metals, whereas the permanent effect of a transverse or a circular field is relatively inappreciable so far as rigidity is concerned. This conclusion is at variance with much of the earlier work on the subject, but the author considers that the step-for-step march towards this result contained in the experiments is not to be evaded. The suggestions of the model agree with the result found. The quantity considered is the *permanent* effect of magnetisation on rigidity, *i.e.*, that which persists after making and breaking the field many times. Besides this there is a very striking temporary effect of marked relative value, the relation of which to viscosity is to be considered in a future paper. J. J. S.

881. *Apparent Hysteresis in Torsional Magnetostriction and its Relation to Viscosity.* **C. Barus.** (Amer. Journ. Sci. 11. pp. 97–110, Feb., 1901.)—The author describes a series of experiments made with iron and nickel wires by twisting the wire alternately back and forward over a definite angle within the elastic limits, and examining the change of rigidity produced by circular

or by longitudinal magnetisation immediately after each twist, and after several repetitions of the magnetisations. It is shown that the effect produced by the first magnetisation after any twist is very different from those produced by subsequent magnetisations, the former being viscous and temporary in character, the latter elastic and permanent. When a wire is strained, certain groups of molecules lag behind the stress; this lag may be annulled gradually by lapse of time or by rise of temperature, but it is suddenly annulled by magnetisation. Thus the first magnetisation after any twist has been imparted to the wire reconstructs the magnetic configurations; the subsequent magnetisations merely deflect the set molecular magnets, thus increasing the rigidity without the accompanying viscous effect. W. C. H.

882. *Electric Tramways and Galvanometric Disturbances.* **H. Chevallier.** (Soc. Int. Élect., Bull. 17. pp. 434–436, Nov., 1900.)—At Charlottenburg the disturbances of the electric tramway system render galvanometric measurements useless within a distance of 4 km. from the feeders. At Potsdam magnetometric observations are interrupted 10 km. from the feeders. At Spandau similar instruments are affected at 1 km. The writer gives figures showing the extent of the disturbances at Bordeaux. R. A.

883. *Relation between Solar Activity and the Diurnal Range of the Declination.* **A. Angot.** (Comptes Rendus, 132. pp. 254–257, Feb. 4; and pp. 317–320, Feb. 11, 1901.)—Angot has applied Fourier analysis to the declination records at Parc Saint Maur and Greenwich, and considered how the values of the coefficients vary with the number of sunspots. He supposes the diurnal variation to be due to a normal wave, corresponding to the condition of the sun where no spots are visible, and a disturbing wave which is a function of the number of spots. He concludes that the numbers obtained clearly indicate the influence of the number of spots in the diurnal range of declination. W. W.

MEDICAL ELECTRICITY.

884. *Electrolytic Treatment of Uratic Deposits.* **H. Bordier.** (Archives d'Él. Médicale, 8. pp. 529–532, Nov., 1900.)—In applying the electrolytic treatment to patients suffering from insoluble uratic deposits in the limbs, the author has observed that besides having the lithium of the lithium chloride solution carried by the current into the body, as evidenced by spectroscopic analysis of the urine, the uric acid is also carried out of the body. A deposit formed in the electrolytic bath was found to contain uric acid, calcium carbonate, and traces of lithium. The calcium carbonate came from the water in which the lithium chloride was dissolved.

While operating to remove the largest deposits, it was found that those deposits which had been treated electrolytically were soft like cream, and that those which had not been so treated were hard as stones. J. B. H.

REFERENCE.

885. *Atmospheric Electricity.* **H. Benndorf.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 923–940, 1900.)—A mathematical inquiry into the relations between the form of the earth's surface and the local atmospheric potential slope. The method is based on a development of the theory of proof-planes, applied to a number of typical configurations. A. D.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

886. *Spectroscopy of Atmospheric Gases.* **Rayleigh.** (Phil. Mag. 1. pp. 100–105, Jan., 1901.)—*On the Visibility of Hydrogen in Air.*—Gautier has found by chemical methods that air normally contains about $\frac{2}{10000}$ of hydrogen in addition to variable amounts of hydrocarbons. This has led the author to repeat some experiments he made on the same subject in 1897, and to further investigate the subject. He finds as before that the C line in the spark spectrum of air at atmospheric pressure is nearly, but never quite, obliterated by careful drying of the air. He also finds that an addition to the dried air of $\frac{1}{3000}$ part of hydrogen (by volume) causes a marked increase in the visibility of C, the increase being such that one could easily believe that the proportion of hydrogen actually operative had been doubled. This conclusion would be in precise agreement with Gautier's result, could we assume that the smaller quantity of hydrogen really accompanied the air. But the facts now to be recorded render this assumption extremely doubtful.

The visibility of C with ordinary air is not perceptibly diminished by passing the air over red-hot cupric oxide, although the author's former experience showed that hydrogen purposely introduced into nitrogen could be so far removed by cupric oxide, that the weight remained sensibly unaffected, although $\frac{1}{10000}$ of residual hydrogen was expected to manifest itself. When air with $\frac{1}{3000}$ of hydrogen is passed over cupric oxide, the additional hydrogen appeared to be removed.

Nitrous oxide prepared from ammonium nitrate and also as supplied commercially in iron bottles, and oxygen prepared from permanganate of potash show the C line of about the same intensity as with air. These experiments indicate the possibility of the hydrogen present being evolved from the glass and electrodes of the sparking chamber. Experiments upon the visibility of the C line in vacuum tubes have shown a much less degree of sensitiveness, air containing 2 per cent. of hydrogen showing the C line of about the same brightness as the spark spectrum of ordinary moist air.

Demonstration at Atmospheric Pressure of Argon from very small quantities of Air.—The nitrogen is removed from 10 or 15 c.c. of air by sparking over dilute alkali, and the spectrum of argon is easily recognisable in the spark spectrum of the residue, even when the argon is diluted with two or three times its volume of oxygen. The arrangement used is described in detail, being suitable for a student's experiment.

Concentration of Helium from the Atmosphere.—A constant stream of carbonic acid gas (3 litres per hour) is maintained for, say, 14 hours through a vertical diffusion tube open above to the atmosphere. This tube is about 40 cm. long and of about 5 cm. diameter. The gases of the atmosphere diffuse downwards into the tube, but the heavier constituents are held at bay by the stream of carbonic acid. A continuous stream is drawn off from a point about half-way down the diffusion-tube, and after the carbonic acid is absorbed by alkali the residue is collected. The residue is a small quantity of atmospheric gases in which nitrogen and helium are relatively much concentrated. This lateral stream is about 250 c.c. per hour, and is maintained by means of a sprengel pump drawing the gases through the walls of a short length of tobacco-pipe. After removing nitrogen in the usual way, the final residue, in the experiment in which D_3 was best seen, was about

0·25 c.c. Argon was plainly visible, and probably constituted the larger bulk. Success depended on precautions taken to avoid the presence of gases, and especially of argon, which had not undergone diffusion, but had come from the carbonic acid generator. J. B. H.

887. *Absorption Spectra: Law of Auxochromic Groups.* **P. Lemoult.** (Soc. Franc. Phys., Bull. 160. pp. 3–4, 1901.)—A group which unites together several aromatic nuclei is a chromophore, the whole forming a chromogen, the nature of the grouping leading to a classification of colouring matters. NH_2 or OH groups in "privileged positions," usually *para*-, in relation to the chromophoric bond, are called *auxochromes:* the former are of three kinds—NH_2 or primary, NHR′ or secondary, and NR′R,″ where R′ and R″ are fatty or aromatic radicles. Alkyls, NO_2, SO_3H, COOH, and even NH_2 and OH in "non-privileged" positions, are called *non-significant;* they add nothing to the colouring function, however important in other ways. Coloured solutions in molecular dilution and of constant thickness, according to the author, give usually a narrow band in the red and often a wider one towards the green or violet. The centre of the red band is constant for the same family in bodies only differing by non-significant groups, or by nitrogenous auxochromes, which are non-tertiary, but is displaced on varying the number of the latter, which are tertiary. These facts together constitute "the law of nitrogenous auxochromes." For triphenylmethane colours, those with two tertiaries with or without a non-tertiary give a red band between 0·70 μ and 0·66 μ, those with three tertiary auxochromes give a band between 0·68 μ and 0·65 μ. The red band of the family is more persistent than any other individual character. Lemoult has found that indophenols obey the same law. S. R.

888. *Absorption of Light by Indophenols.* **P. Bayrac** and **C. Camichel.** (Comptes Rendus, 132. pp. 338–340, Feb. 11, 1901.)—All indophenols derived from p-anudo-dimethylamme, when dissolved in alcohol give an analogous spectrum with a characteristic red band, and do not conform to Lemoult's law of auxochromes [Comptes Rendus, 131. No. 21; see also preceding Abstract]. This band commences in the visible spectrum and extends into the infra-red. S. R.

889. *Absorption Spectra of Indophenols and of Derivatives of Triphenylmethane.* **C. Camichel** and **P. Bayrac.** (Comptes Rendus, 132. pp. 485–487, Feb. 25, 1901.)—The authors further show that Lemoult's law of auxochromes does not apply to the coloured derivatives of triphenylmethane [see preceding Abstracts]. S. R.

890. *Molecular Rotation of Normal Acidyl Derivatives of Diethyl l-Malate.* **H. Reitter.** (Zeitschr. Phys. Chem. 36. pp. 129–167, Feb. 8, 1901.)—According to the theory of the asymmetric carbon atom elaborated by Guye, the optical rotation depends in the first place on the relative masses of the radicles with which the asymmetric carbon atom of the molecule is combined, and the specific rotation is proportional to the so-called asymmetry-product, the value of which is given by the following expression, in which a, b, c, and d are the masses of the four radicles :—

$$P = \{(a-b)(a-c)(a-d)(b-c)(b-d)(c-d)\}^{\frac{1}{2}}/(a+b+c+d)^6.$$

In the case of several homologous series which have been examined it has

been found that proportionality between the specific rotation and the asymmetry-product does not exist, and in some cases the two magnitudes do not vary in the same manner. The compounds examined by the author comprise the first normal acidyl derivatives of lævo diethyl malate and a description of their methods of preparation and of their properties is given. The results obtained are given in the following table, the first column containing the names of the various acidyl derivatives :—

	Mol. Wt.	Density 20°/4°	$[\alpha]_D^{20}$	$[M]_D^{20}$	$P \times 10^6$
Acetyl	232	1·1169	— 22·60	— 52·43	17
Propionyl ...	246	1·0926	— 22·79	— 56·06	0
n-Butyryl ...	260	1·0735	— 22·75	— 59·15	0
n-Valeryl.....	274	1·0551	— 21·38	— 58·56	11
n-Capronyl ...	288	1·0420	— 20·30	— 58·46	26
Œnanthyl ...	302	1·0289	— 19·30	— 58·27	44
Caprylyl	316	1·0162	— 18·21	— 57·53	61
Pelargonyl ...	330	1·0073	— 17·24	— 57·17	77
Caprinyl	344	1·0011	— 16·61	— 57·14	91

These numbers furnish a further contradiction to the supposed proportionality between specific rotation and asymmetry-product, as when the former is at its maximum the latter has the value 0. The numbers obtained for the molecular rotation confirm what has been previously found for other homologous series, namely, that the molecular rotation tends to become constant as the series is ascended. T. H. P.

891. *Apparent Symmetry in Crystals.* **F. Wallerant.** (Comptes Rendus, 132. pp. 178–180, Jan. 21, 1901.)—When the network and the fundamental particle of a crystallised body possess a common element of symmetry, this element is found also in the crystalline form and in the ellipsoid of optical elasticity. In most cases the converse of this also holds, and it has hence been assumed that it holds generally, although in some cases an axis of the crystal and of the optical ellipsoid may not be of the same order of symmetry as the network, as will be seen from the following considerations. Iodargyrite shows hexagonal symmetry in its crystalline form, but its network and its fundamental particle have only a ternary axis, which has, however, an apparent binary symmetry. This view is supported by the facts—(1) that the parameters of the vertical and secondary axes are in the ratio 1·2294 which is almost exactly $\sqrt{3}/\sqrt{2}$; so that if the network were hexagonal, there would be no relation between the vertical and secondary axes ; (2) that the crystals twin along the face (1012) which makes an angle of 54° 38′ with the ternary axis ; this arrangement cannot be explained if the crystal be hexagonal, whilst if the symmetry be cubic, the plane of twinning coincides with a rhombic dodecahedron face, which makes an angle of 54° 44′ with the ternary axis of the cube ; (3) that when heated to 146° iodargyrite becomes cubic, reverting to its original form on cooling ; as this change is effected without loss of transparency, it follows that the network, which is cubic above 146°, must be rhombohedric and not hexagonal below that temperature. As further examples may be cited rutile and other minerals regarded as quadratic, but which are really monoclinic. It hence becomes necessary to introduce into crystallography a new idea, that of an axis of apparent symmetry, which is

such that when the network is rotated round it through an angle of $2\pi/n$, any particular row or plane of the network is brought into coincidence with another row or plane, but the coincidence does not hold for the whole network. Another necessary condition for a row being such an axis of apparent symmetry is that the fundamental particle exerts, in symmetrical directions, equal actions on external media such as the ether. T. H. P.

892. *Crystallisation of Solid Metals by Pressure.* **W. Campbell.** (Phys. Soc., Proc. 17. pp. 337–338; Discussion, p. 338, Dec. 1900 [Abstract].)—When a button of slowly-cooled tin is hammered it assumes a fine crystalline structure. Also in preparing sections of tin, particles of the metal cling to the file and tend to tear the surface; this effect is not immediately noticeable, but on etching the polished surface, there appear, besides the usual structure of the tin irregular outlines of much smaller crystals, and if the tearing action of the file has been extreme, these crystals may conceal the original crystalline formation produced by cooling. A similar crystallisation is brought about on the faces of a saw-cut. A copper-tin alloy containing 1 per cent. of copper, gives exactly the same effects as pure tin. That the crystallisation exists only on the surface of the metal is shown by gradually wearing away the surface by continually polishing, when it is found that the crystals slowly disappear, giving place to the ordinary structure. The effect is not due to local heating, since if the file is kept perfectly clean no crystals are formed. T. H. P.

893. *Crystal Symmetry.* **W. Barlow.** (Phil. Mag. 1. pp. 1–36, Jan., 1901 Published also in Groth's Zeitschr. f. Krystallographie.)—In seeking a new definition of crystal symmetry, the author points out that it is necessary to have regard not only to the crystal form of such bodies but also to the physical properties, such as their behaviour with polarised light, and their different degrees of vulnerability in different directions when attacked by solvents. The derivation from first principles of the thirty-two classes of crystal symmetry, now generally recognised, was originally achieved by Hessel, and rediscovered much later by Gadolin; both writers base their work on the validity of Haüy's law of rational indices as applied to crystal faces, and discuss the symmetry solely with reference to face directions. Barlow now shows that this treatment lacks generality, and that it leads in some cases to crystals being referred to types of symmetry higher than that characterising their internal structure. He submits a definition of homogeniety of structure which is independent of face directions, and proves that this definition suffices as a basis both for the deduction of the thirty-two classes, and for that of Haüy's law connecting homogeneous planes and lines of points occupying identical situations. R. A.

894. *Reaction Velocity, and Solubility.* **W. D. Bancroft.** (Archives Néerlandaises, 5. pp. 46–48, 1900.)—The recent experiments of Buchböck [see Abstract No. 2270 (1900)] have shown that the viscosity of the solvent is one of the factors determining the velocity of a reaction. The fact that the order of the solvents is not the same for all reactions shows that other influences than that of viscosity come into play, and the author indicates the effect produced on the velocity by the solubilities of the reacting compounds. Taking the case of a monomolecular reversible reaction in a so-called indifferent solvent, equilibrium occurs when $k_1c_1 = k_2c_2$ and the velocity of reaction at any moment is given by: $dc/dt = k_1c_1/A - k_2c_2/A$, the factor A

representing the effects due to viscosity and to other as yet unclassified causes. If now another solvent be employed in which the first substance is less soluble and the second more soluble than before, k_1 becomes replaced by the larger constant k_1' and k_2 by the smaller k_2', the equilibrium being displaced to the side of the second substance. If the change of the solvent introduces no disturbing elements other than the change of solubility, the velocity of reaction at any moment will be: $dc/dt = k_1'c_1/A - k_2'c_2/A$. Hence a decrease in the solubility of one of the reacting substances tends to increase the rate at which the other is formed It does not follow that the velocity of reaction will be increased in any particular case, because it is extremely improbable that the change of solubility will be the only change produced by the substitution of a new solvent, and it is conceivable that there might be an increase in the factor A which would more than counterbalance the changes in k_1 and k_2. T. H. P.

895. *Microscopic Examination of Tool-Steel.* **E. Heyn.** (Tech. Versuch. Berlin, Mitth. 18. pp. 191–202, 1900.)—In order to ascertain whether the working-edge of a tool has become richer or poorer in carbon than the rest of the tool, a fragment is heated in an atmosphere of nitrogen, ground and polished, and then etched with a mixture of 1 part hydrochloric acid and 99 parts alcohol. In steels containing less than 0·9 per cent. carbon the relative proportion of carbon may be judged from the quantity of yellowish perlite which can be seen, as compared with the clear ferrite (pure iron); in steels containing more than 0·9 per cent. carbon, the white cementite may be used as a test in a similar way. Directions are also given for detecting welds and hardening cracks.

In order to ascertain whether the steel has been burnt in making the tool, whether it has been tempered after hardening, from what temperature it was quenched in the hardening, and whether it was overheated in hardening, it is necessary to know the influence of these changes on the minute structure of steel, and experiments are described which were carried out with a steel containing 0·55 per cent. of carbon in order to obtain some of the necessary data. T. M. L.

896. *Eutectic (Cryohydric) Curves in Systems of Three Substances, Two being Optical Antipodes.* **J. H. Adriani.** (Zeitschr. Phys. Chem. 36. pp. 168–172, Feb. 8, 1901.)—Bruni has shown that the cryohydric curve for solutions of various mixtures of two optical antipodes varies in form according as the mixture of the two isomerides separates from solution as a racemic substance, as mixed crystals, or as a mixture. In place of the term "cryohydric" curve the author suggests "eutectic" as applying to other solvents as well as water, and to eliminate the false distinction made between solvent and dissolved substance the former is termed the "third body." By choosing for the third body substances having different melting-points, it is found that in general the region of temperature of the eutectic curve is highest in the case of that third body which has the highest melting-point, and any change in the nature of the inactive substance with change of temperature will be accompanied by a change in the form of the eutectic curve. The author applies this method to the case of the camphoroximes, the racemic modification of which he has previously [see Abstract No. 1700 (1900)] shown to change above 108° into mixed crystals. Four solvents—naphthalene, phenanthrene, benzoin, and

anthracene—were employed, and the various eutectic temperatures for the different mixtures are given in the following table :—

Percentage.		Naphthalene M. Pt. 81·4°.	Phenanthrene M. Pt. 99·4°.	Benzoin M. Pt. 137°.	Anthracene M. Pt. 213°.
d-oxime.	*l*-oxime.				
100	0	61·0°	76·2°	100·2°	109·2°
95	5	60·0	—	—	—
90	10	59·6	75·6	99·1	107·6
80	20	59·2	74·9	98·2	106·8
75	25	59·4	—	97·8	—
70	30	60·1	74·2	97·4	106·2
65	35	60·8	74·8	—	—
60	40	61·3	75·6	97·0	105·8
50	50	61·9	76·2	97·2	105·6

These numbers show that at 60° the eutectic temperature of the *i*-oxime is higher than that of the two antipodes, the difference becoming smaller as the temperature increases until in the neighbourhood of 76° (phenanthrene) the eutectic points of the *i*-compound and of the antipodes are the same. At still higher temperatures the change continues, and the numbers obtained with benzoin indicate that at 97·2° camphoroxime still exists in the form of a racemic substance. The anthracene curve is, however, continuous, showing that at 105·6° *i*-camphoroxime must be regarded as mixed crystals. The transition-point hence lies between 97·2° and 105·6°—a result agreeing with that previously obtained (*loc. cit.*). T. H. P.

897. *Catalysis in Heterogeneous Systems.* **K. Drucker.** (Zeitschr. Phys. Chem. 36. pp. 173–215, Feb. 8, 1901.)—Experimental investigations in chemical kinetics have hitherto been principally confined to homogeneous systems ; the author has therefore studied two cases of catalytic reactions in solid-liquid systems, namely, the dissolution of anhydrous chromic chloride and of arsenic trioxide in aqueous solvents. The results of the experiments, full details of which are given in the paper, are summarised as follows : The effect of reducing agents (other substances being inactive) in increasing the velocity of solutions of chromic chloride in water depends (1) on the nature of the reducing agent, no regularities being detected in this respect ; (2) on its reduction potential, with which it rises and falls ; (3) on its concentration, a similar relation holding. If the reducing agent is soluble with difficulty it is necessary that the solid substance should be present, and the effect produced depends on the surface of the latter and on the contact of the two solid phases. The reaction follows Noyes' and Whitney's relation, the velocity being constant in the initial stages. For slow and very rapid reactions the velocities are nearly proportional to the reduction potential, but for intermediate values this is not the case.

The velocity of solution of arsenic trioxide in water is especially influenced by the presence of hydrogen ions. Noyes' and Whitney's law is found to hold, but the usual influence of the concentration of the catalytic agent was not observed. Hydroxyl ions are also effective ; so also is a solution of sodium acetate, in which, however, few hydrogen or hydroxyl ions can be present. Amyl alcohol has a slight retarding action. N.I.

898. *Chemical Kinetics of Homogeneous Systems.* **R. Wegscheider.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 699–792, 1900.)—The author develops a general form of the equations for the velocities of reactions in homogeneous systems at constant volume, applicable to the various kinds of reactions and catalytic effects. By its means he investigates the form of the reaction equations and the external conditions to be fulfilled (1) in order that the velocities of two simultaneously occurring reactions should be in a ratio independent of the time, (2) that the concentration of a substance which is being partially formed and partially broken up by simultaneous reactions should remain unchanged, (3) that the changes in the quantities of two substances should be in a ratio independent of the time. The results are applied to the study of Skraup's constant "transmutation-ratio," and it is shown that such a ratio, determinate, finite, and independent of the time, exists for two substances (1) when the concentrations of both are changed during the reactions in equal stoichiometric ratios, (2) when the velocities of the reactions which change the concentrations of both substances are in a ratio independent of the time. Cinchona is treated as an example. In conclusion the author investigates equations for the velocities of reactions, when the volume changes are taken into account, particularly in the case of gases under constant pressure. The formulæ arrived at are applied to the discussion of Bodenstein's experiments on the formation of water-vapour from Knall gas, and the importance of paying attention to the volume changes that occur is demonstrated. The reaction occurs more slowly at constant volume than at constant pressure. W. E. T.

899. *Dissolution of Solid Metals in Liquid Metals.* **Berthelot.** (Comptes Rendus, 132. pp. 290–291, Feb. 11, 1901.)—The author draws attention to the fact that the phenomenon of solution of a solid metal by a liquid metal is by no means analogous to the solution of a salt or other compound body by water. The action, for example, of a small quantity of mercury in gradually penetrating another metal, such as gold, silver, copper, or zinc, which is thereby caused to swell up and become soft and brittle, is not strictly a case of solution. The author points out that the thermo-chemical data of his experiments on the heats of transformation of the allotropic forms of silver, and on the heats of formation of silver amalgams, are independent of any theory as to the constitution of the supposed metallic solutions. T. H. P.

900. *Determination of the Work Produced by Chemical Change.* **E. Cohen.** (Archives Néerlandaises, 5. pp. 295–305, 1900.)—The vapour tension of crystals of $MgSO_4.7H_2O$ was determined at temperatures between 30·75 and 47·45° C.; from the values obtained the heat of hydration was calculated to be 3,712 cal., the value given by Thomsen's calorimetric measurements being 3,700 cal. Similarly the vapour tension of $FeSO_4.7H_2O$ was determined between 30·67 and 46·43° C., and the heat of hydration calculated to be 1,912 cal. The two vapour-tension curves intersect at 46·6° C., which is thus the transition-point of the system—

$$FeSO_4.6H_2O + MgSO_4.7H_2O \rightleftarrows FeSO_4.7H_2O + MgSO_4.6H_2O;$$

above this temperature $FeSO_4.7H_2O$ has the lower vapour pressure, whilst below 46·6° the vapour pressure of the $MgSO_4.7H_2O$ is the lower.

If q is the heat of the reaction and P the transition temperature, then the work, A, in calories available at T° (abs.) is given by the equation—

$$A = q\left(\frac{P - T}{P}\right),$$

and in this case $A = 1800 - 5{\cdot}632T$. T. M. L.

901. *Use of Pyridine for Molecular Weight Determinations by the Ebullioscopic Method.* **W. R. Innes.** (Chem. Soc., Journ. 79. and 80. pp. 261–266, Feb., 1901.)—Pyridine does not favour the association of dissolved substances, acids, alcohols, and phenols having been found to give normal results. Hence this liquid may be used for ebullioscopic molecular weight determinations—a purpose for which it is well fitted on account of its remarkable solvent power for both organic and inorganic compounds. The precautions necessary to obtain accurate results are described in the paper; the constant for pyridine is 29·5. N. L.

902. *Gas-Polarisation in Lead Accumulators.* **C. J. Reed.** (Journ. Phys. Chem. 5. pp. 1–16, Jan., 1901.)—The statement of Nernst and Dolezalek [Abstract No. 671 (1901)] that hydrogen is not liberated with less than 2·3 volts from lead electrodes, as compared with 1·7 volts for platinum electrodes, is incorrect; on the contrary, hydrogen gas is evolved electrolytically in unlimited quantities from dilute sulphuric acid with electrodes of pure metallic lead when the e.m.f. is less than 0·5 volt. To realise this experimentally it is necessary to employ a very large anode of finely divided lead, since the surface rapidly becomes covered with lead sulphate. The reaction which first takes place is expressed by the equation—

$$Pb + H_2SO_4Aq = PbSO_4 + 2H + Aq,$$

and should produce an e.m.f. of 0·12 volt; actually 0·38 volt is required to start the reaction, but the e.m.f. then required to maintain a steady current is less than 0·01 volt.

As soon as the anode is covered with a film of lead sulphate the character of the reaction changes to that expressed by the equation—

$$PbSO_4 + H_2SO_4Aq = 2H + PbO_2 + 2SO_3Aq,$$

which, instead of producing an e.m.f., absorbs an e.m.f. of 1·73 volts. If, as in a discharged accumulator, the kathode is not lead but lead sulphate, this must also be reduced, and the reaction—

$$Aq + 2PbSO_4 = PbO_2 + Pb + 2SO_3Aq,$$

requires 1·845 volts. If a correction is made for the fact that the acid in the accumulator is of appreciable concentration, slightly higher values would be obtained for the voltage, and these corrected values correspond with the observed e.m.f. of the cell. T. M. L.

903. *Equilibrium of Mixed Crystals with the Gaseous Phase.* **H. W. B. Roozeboom.** (Archives Néerlandaises, 5. pp. 360–365, 1900.)—The case considered is that of a system of two substances which are miscible in all proportions, both in the solid and in the liquid state; it is also assumed that the vapour-pressure curves for mixtures of the two substances in different proportions are continuous and do not show a maximum or minimum. If the vapour pressure is plotted along a vertical axis, and the temperature and percentage composition are plotted along a pair of horizontal axes, the vapour surface consists of two sheets representing the pressure and composition of the vapour in equilibrium with the solid and with the fused mixture respectively. The surfaces representing the vapour pressure of solid and of liquid mixtures of different composition form two separate sheets, which are separated by a small surface representing solid and liquid in equilibrium.

At the melting-point of the mixed crystals three phases are in equilibrium,

under the same pressure, the solid phase being richest and the vapour phase poorest, in the less fusible and less volatile constituent. For any temperature between the melting-points of the two constituents a horizontal line of equal pressures can therefore be drawn passing successively through the three boundaries of the surfaces described above. T. M. L.

904. *Dissociation Constants of Alkyl-substituted Succinic Acids.* **W. A. Bone** and **C. H. G. Sprankling.** (Chem. Soc., Journ. 77. and 78. pp. 654–673; and pp. 1298–1310, 1900.)—The authors give the results of a number of measurements of the dissociation constants of alkyl-substituted succinic acids, together with a discussion of the connection between the values obtained and the chemical constitution of the various derivatives. The values of the dissociation constants of such acids should be influenced by (1) the number of substituting alkyl groups, (2) their mass and chemical structure, and (3) the mutual influence of the two carboxyl groups, largely dependent on the distance between them. From observations on anhydride formation, the authors incline to the view that the relative distances of the two carboxyl groups in acids of this series containing the same number of alkyl radicles are practically equal, so that differences in their dissociation constants must be ascribed to the influence of the second factor, namely, mass or chemical structure of the alkyl substituents. The constants for mono-substituted succinic acids are as follows :—

Monomethyl.....	0·0085	Monoisopropyl	0·0076
Monoethyl	0·0085	Monoisobutyl.....	0·0088
Monopropyl	0·00886	Monoisoamyl	0·0096

Hence, for these acids, an increase in the mass of the alkyl radicle is accompanied by a tendency to increase in the constant, except in the case of the isopropyl group, which exerts a lowering influence. On comparing the values obtained for the aa_1-dialkyl acids containing one methyl and a second variable radicle, which are as follows :—

	Trans.	Cis.
s-Dimethyl	0·0196	0·0123
aa_1-Methylethyl	0·0207	0·0201
aa_1-Methylpropyl.....	0·0335	0·0271
aa_1-Methylisopropyl	0·0158	0·066
aa_1-Methylisobutyl	0·0226	0·056
aa_1-Methylisoamyl	0·0236	0·0385

it will be seen that, so long as the variable radicle remains normal, the constant increases with its mass in both the cis- and trans-series. When, however, the variable radicle contains an iso-grouping, a lowering effect is found in the trans-series and a marked increase in the cis-series, these two opposite effects becoming greater as the peculiar grouping of the atoms in the iso-radicle approaches more nearly to the carbon atom to which the carboxyl group is attached. Further, only where the variable radicle is normal are the constants for the trans-acids greater than those for the corresponding cis-isomerides. Similar effects are to be observed in the case of trialkyl acids having two methyl groups attached to the one carbon atom and a third variable radicle to the other carbon atom, thus :—

Trimethyl	0·0320	Dimethylisopropyl	0·0150
Dimethylethyl	0·0566	Dimethylisobutyl	0·0432
Dimethylpropyl.....	0·0600	Dimethylisoamyl	0·0616

and also in the case of the symmetrically substituted dialkylsuccinic acids, the constants for which are given in the following table :—

	Trans.	Cis.
s-Dimethyl	0·0196	0·0123
s-Diethyl	0·0245	0·0201
s-Dipropyl	0·0250	0·049
s-Diisopropyl	0·0108	0·230
s-Diisobutyl	0·0226	0·056

The general conclusion to be drawn from all these results is that in this series of acids each alkyl group exerts on the dissociation constant its own influence dependent on its mass and structure. In the case of normal substituents, where the effect of mass only has to be considered, it is found that an increase in the mass of a variable radicle is invariably accompanied by an increase in the dissociation constant. With the one exception of cis-symmetrically substituted dialkyl acids, the "structural" effect of the iso-radicles is opposed to the mass effect and its magnitude in all cases depends on the proximity of the iso-linking to the carbon atom bearing the carboxyl group. T. H. P.

905. *Potential between Metals and Non-aqueous Solutions.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 709–714, Dec., 1900.)—This paper is a continuation of the one referred to in Abstract No. 545 (1900). The author tests the well-known formula of Nernst for cells of the type—

$$\mathrm{Ag} \mid \mathrm{AgNO_3\ (concentrated)} \mid \mathrm{AgNO_3\ (dilute)} \mid \mathrm{Ag},$$

with organic solvents. If the degree of ionisation is taken into account, the formula becomes—

$$E = \frac{RT}{ne} \log \frac{S_1 \mu_{s1}}{S_2 \mu_{s2}},$$

in which S_1, S_2 are the concentrations, and μ_{s1}, μ_{s2} are the corresponding degrees of ionisation. Five combinations were tested, with the following results :—

	E.m.f. calculated.	E.m.f. found.
Ag electrodes : N/10 and N/100 $AgNO_3$ in pyridine...	0·052 volt	0·035 volt
„ „ N/500 „ „ ...	0·085 „	0·061 „
„ „ N/1,000 „ „ ...	0·099 „	0·076 „
„ N/8 and N/128 „ in acetonitrile	0·050 „	0·046 „
Cd electrodes : 1 gr. mol. of CdI_2 in 48·9 litres and in 214·7 litres of acetonitrile.....	0·017 „	0·032 „

Any potential difference between the solutions was neglected. The author concludes that the formula does not apply to non-aqueous solutions. It is noticeable that the only case of approximate agreement is the fourth combination, in which the electrolyte is of high conductivity. W. R. C.

906. *Electrode-Potentials.* **N. T. M. Wilsmore** and **W. Ostwald.** (Zeitschr. Phys. Chem. 35. pp. 291–332, Nov. 2, 1900; and 36. pp. 91–98, Jan. 22, 1901.)—The author proposes the name *Electrolytic Potential* for the quantity $\frac{RT}{n} \log P$ of Nernst's theory. In order to carry through the suggestion of Nernst, that the p.d. of hydrogen at atmospheric pressure against an aqueous solution containing hydrogen ions of normal concentration should be

taken as zero for electro-chemical calculations, the author very fully investigates this particular electrode and describes and figures a suitable form, wherein the gas continually bubbles through the electrodic solution. Reckoning in this way, the p.d. of the normal calomel-mercury electrode comes out to be —0·283 volt. Incidentally the curious fact is observed that the e.m.f. of the $H_2 — O_2$ gas-cell (normal sulphuric acid) gradually *rises* after the cell is set up, becoming approximately constant after four to six days at the value 1·119 volts (initial value, 1·076 volts). The paper further contains a very exhaustive summary of the literature on the subject, from which the electrolytic potentials of thirty-one elements are calculated, and investigations on various other electrodes, more especially on kathodically-polarised platinum wire-points.

In the second paper the author gives a recalculation of the potentials given by him in a previous paper, on the basis preferred by Ostwald, namely, using the calomel-electrode and taking its p.d. as 0·56 volt. Appended to the original are some remarks by both authors on the *pros* and *cons* of the case, hydrogen- *versus* calomel-electrode as a basis in the determination of p.d.'s in electro-chemistry. [See also Abstract No. 414 (1901).] F. G. D.

907. *Determination of Transport Numbers, and the Influence of Concentration.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 36. pp. 63–83, Jan. 22, 1901.)—In determining the transportation-values for salts, the metal of which cannot be used for the electrodes, the chief difficulty is caused by the formation of acid and alkali at the anode and kathode, and the rapid diffusion of the $\overset{+}{H}$ and $\overset{-}{OH}$ ions into the solution. This makes it necessary to interrupt the experiment when only a few milligrammes have been transported, and largely increases the errors of experiment. In the method now described this difficulty is overcome by neutralising the liquid at the electrodes with solutions of suitable strength of the acid and base of the salt, and measurements of remarkable accuracy can be obtained.

The method has been used to ascertain to what extent the transportation values are influenced by the concentration in the case of the three ternary electrolytes, K_2SO_4, $BaCl_2$ and $Ba(NO_3)_2$. The existence of the ions $\overset{-}{KSO_4}$, $\overset{+}{BaCl}$ and $\overset{+}{BaNO_3}$ cannot be established by measurements of the conductivity or freezing-point of the solutions, and there is no method of estimating them comparable with the determination of hydrogen ions by experiments on inversion and hydrolysis; their presence would, however, have the effect of diminishing the transportation-value of the kathion in the case of K_2SO_4, and of the anion in the case of $BaCl_2$ and $Ba(NO_3)_2$. In the case of barium nitrate at 25° the transportation-values for the kathion were found to be 0·4550 in 0·1 molecular solution, and 0·4559 in 0·02 molecular solution, showing that dissociation into $\overset{+}{BaNO_3}$ and $\overset{-}{NO_3}$ only takes place to a very slight extent. In the case of potassium sulphate the corresponding values were 0·4931 and 0·4962, showing that not more than 1 per cent. of the salt can be present in the intermediate stage of ionisation. Barium chloride, however, showed a very marked influence of concentration, and gave the values 41·47 and 44·22 in 0·1 and 0·02 molecular solution at 25°; this effect is in the opposite direction to that which would be produced by ionisation into $\overset{+}{BaCl}$ and $\overset{-}{Cl}$, and it is suggested that the anion tends to combine with the neutral salt to complex ions such as $\overset{-}{BaCl_3}$ or $\overset{=}{BaCl_4}$. Hittorf's values for $BaCl_2$ and $Ba(NO_3)_2$

are widely different from those now given, and show that fresh determinations of the transportation-values of ternary electrolytes are needed. T. M. L.

908. *Calculation of the Ionisation of Strong Electrolytes.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 36. pp. 28–40, Jan. 22, 1901.)—Using Nernst's formula for the e.m.f. of concentration-cells, Jahn has recently endeavoured to prove that the ionic mobilities vary comparatively rapidly with concentration, so that the present method of calculating the degree of ionisation from the conductivity of a solution is incorrect. This conclusion is now contested by Arrhenius. He first of all deduces thermodynamically a formula for the e.m.f. of concentration-cells, which differs from that given by Nernst. For example, in the cases quoted, the difference between the values as calculated from the two formulæ amounts to about 1½ per cent. Arrhenius points out the cause of this difference. It is due to the fact that Nernst's formula results from the summation of three terms, one of which is the p.d. at the junction between two electrolytes containing the same ions but of different concentrations. In calculating this p.d. it is assumed by Nernst that an ion when it passes across this interface from one solution to the other remains still an ion. This, however, is only true for extremely dilute electrolytes.

In order now to test how far the discrepancies observed by Jahn originated from the use of Nernst's formula, Arrhenius calculates from his data the degrees of ionisation by the usual conductivity method, and then employs the values so found to calculate the true e.m.f.'s of the concentration-cells. On comparing these values with those experimentally determined, the difference is found to be small, the average discrepancy being about 1½ per cent. These differences are, at any rate, very much smaller than the differences supposed by Jahn to exist between the ionic mobilities in the weakest and strongest solutions examined by him, and are considered by Arrhenius to be due to the experimental difficulties inherent in the determination of e.m.f.'s. In view of this, Arrhenius considers that Jahn's experiments, instead of overthrowing the old method of determining degrees of ionisation, form a further confirmation of it, and he maintains that the anomalous behaviour of strong electrolytes cannot be explained in the manner indicated by Jahn.

[The thermodynamical formula for the e.m.f. of concentration-cells given by Arrhenius is not new. It has been given recently by Couette and subsequently by Lehfeldt.] F. G. D.

909. *Autoxidation, Theory of Ions, and Galvanic Cells.* **F. Haber.** (Zeitschr. Elektrochem. 7. pp. 441–448, Jan. 31, 1901.)—Hydrogen peroxide is often formed during atmospheric oxidation in accordance with the typical scheme of "autoxidation" $M + O_2 + 2H_2O = M(OH)_2 + H_2O_2$. Taking as an example the conversion of lead to sulphate according to the equation $Pb + H_2SO_4 + O_2 = PbSO_4 + H_2O$, it is shown that this can be resolved into a characteristic anode-reaction—

$$Pb + SO_4 = PbSO_4$$

and a kathode-reaction—

$$O_2 + 2H = H_2O_2$$

which has been shown by Traube and by Richarz and Lonnes to take place at kathodes of amalgamated gold and other materials. The whole phenomenon is therefore probably, like many other chemical reactions, electrolytic in character. T. M. L.

910. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Comptes Rendus, 132. pp. 128–131, Jan. 14, 1901.)—If a mixture of carbon dioxide and sulphur dioxide undergoes isothermal compression, between a certain value of the pressure corresponding to the dew-point and a higher value corresponding to the point of ebullition, or the second dew-point, the system consists of a double mixture, in which liquid and gaseous phases occur. The author applies the limiting lines obtained by him [see Abstracts Nos. 843 and 2004 (1900)] to the determination of the concentrations in these phases, when the temperature and pressure are given. Curves are drawn which represent the connection between the concentrations and the pressure for five temperatures. [See further Abstract No. 625 (1901).] W. E. T.

911. *Relations between the Quantities Characteristic of the Physical State of a Solution.* **N. Schiller.** (Archives Néerlandaises, 5. pp. 118–147, 1900.)—For a given temperature, letting σ_0 signify the specific volume of a pure solvent under pressure p_0, σ the specific volume of the solvent forming a solution of concentration ζ (the ratio of the quantity of the dissolved substance to the quantity of the solvent) under pressure p_0; κ_0, κ the elasticity coefficients of the pure solvent and of the solution, q the osmotic pressure in the solution under the pressure of the vapour arising from it, q_1 the osmotic pressure in the solution of concentration ζ under external pressure $p_0 + q_1$, σ_1 the specific volume of the solvent in the solution corresponding to the pressure $p_0 + q_1$, p_0 the vapour pressure of the pure solvent, p its vapour pressure as modified by the osmotic pressure, the author, neglecting magnitudes of the order $1/\kappa^2$, proves the relations—

$$\frac{\sigma}{\kappa} - \frac{\sigma_0}{\kappa_0} = C\zeta^{\frac{1}{3}},$$

C being an arbitrary constant independent of ζ,

$$\sigma_1 - \zeta\frac{d\sigma_1}{d\zeta} - \sigma_0 = -\frac{1}{2}(p_0 + q_1)C\zeta^{\frac{1}{3}},$$

and—

$$p_0 s_0 \log\frac{p}{p_0} + \sigma_0(p_0 + q - p) + \frac{\sigma_0}{2\kappa_0}(p_0 + q - p)^2 = 0,$$

in which s_0 is the corresponding specific volume of the vapour. These equations are derived from considering the pure solvent and the solution contained in a cylinder fitted with movable pistons, separated by a semi-permeable membrane and subjected to the following isothermal reversible cyclic process. A quantity dm of the solvent passes into the solution, the membrane is replaced by a solid wall, and the external pressure on the solution is brought down to p, dm of the solvent is allowed to evaporate from the solution, separated from the fluid by a solid wall, compressed till its pressure rises to p_0, then till it is liquefied under the pressure p_0, and finally till the fluid regains its original specific volume, when the pressure on the solution is brought back to its original amount. Further relations are derived from considering the quantities of heat necessary to make these changes isothermal. W. E. T.

912. *Conductivity of Salts and of Sodium dissolved in Liquid Ammonia.* **E. Legrand.** (Écl. Électr. 26. pp. 88–98, Jan. 19, 1901. Extracts from a thesis presented to the Faculty of Sciences of Paris, June 22, 1900.)—The method of determining the resistance depends on passing a current through the ammoniacal solution in series with a megohm resistance and comparing

the p.d. at the terminals of the resistance with that near the two electrodes of the electrolytic cell; for the latter calomel electrodes were used with alcohol in place of water to prevent freezing. The electrolyte was cooled by adding solid carbon dioxide to a bath of acetone.

Experiments were made with twenty-three different salts, especially the chlorides, iodides, and nitrates. The resistances of these solutions show positive temperature-coefficients, similar in magnitude to those observed with aqueous solutions at about 51°. The molecular conductivities do not, however, show any tendency to reach a limiting value as the dilution increases, and cannot be represented as the sum of two quantities representing the conductivity of two ions. Values are also given of the conductivity at — 30° of mixtures of ammonia and water in different proportions.

Solutions of sodium in liquid ammonia conduct without any marked deposition on the electrodes, without liberation of gas, and with only slight signs of polarisation; the conductivity increases with the temperature, however, and the conduction is therefore probably electrolytic.

No simple relationship could be traced between the conductivity of the solutions and the viscosity of the solvent. T. M. L.

913. *Conductivities of Aqueous Solutions of Alkali Chlorides and Nitrates.* **F. Kohlrausch** and **M. E. Maltby.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 155–227, 1900.)—This is the official publication by the Reichsanstalt of the research of which a preliminary report has already been given. [See Abstract No. 250 (1900).] The conductivities here determined will serve as standard, since every possible source of error has been allowed for or eliminated—

EQUIVALENT-CONDUCTIVITY AT 18°.

m gr-Equiv. Litre.	KCl	NaCl	LiCl	KNO_3	$NaNO_3$	$LiNO_3$	v Litre gr-Equiv.
0·0001	129·07	108·10	98·14	125·50	104·55	94·46	10,000
0·0002	128·77	107·82	97·85	125·18	104·19	94·15	5,000
0·0005	128·11	107·18	97·19	124·44	103·53	93·52	2,000
0·001	127·34	106·49	96·52	123.65	102·85	92·87	1,000
0·002	126·31	105·55	95·62	122·60	101·89	91·97	500
0·005	124·41	103·78	93·92	120·47	100·06	90·33	200
0·01	122·43	101·95	92·14	118·19	98·16	88·61	100
0·02	119·96	99·62	89·91	115·21	95·66	86·41	50
0·05	115·75	95·71	86·12	109·86	91·43	82·72	20
0·1	112·03	92·02	82·42	104·79	87·24	79.19	10
0·2	107·96	87·73	77·93	98·74	82·28	75·01	5
0·5	102·41	80·94	70·71	89·24	74·05	67·98	2
1	98·27	74·35	63·36	80·46	65·86	60·77	1
2	92·6	64·8	53·1	69·4	54·5		$\frac{1}{2}$
3	88·3	56·5	45·3	(61·3)	46·0		$\frac{1}{3}$
5		42·7	33·3				$\frac{1}{5}$
10			11·3				$\frac{1}{10}$

These figures are also represented graphically in the paper, the abscissæ

being the cube root of the concentration, *i.e.*, the linear-concentration, and the ordinates being the equivalent-conductivities. The form of these curves for low concentration approaches that of a parabola. The different equations which have been proposed for this part of the curve are discussed. J. B. H.

914. *Effect of Potassium Chromate in Diminishing Kathodic Depolarisation.* **E. Müller.** (Zeitschr. Elektrochem. 7. pp. 398-405, Jan. 3, 1901. From the Zeitschr. Anorg. Chem. 26. 1, with alterations.)—The author has observed previously [see Abstract No. 1408 (1899)] that in the electrolytic production of chlorate by the electrolysis of alkaline chlorides, the reduction at the kathode of the hypochlorite produced at the anode is greatly diminished, and hence the output of chlorate greatly increased, by the addition of small quantities of alkaline chromate. In the present paper the author examines various hypotheses whereby this effect may be explained, and arrives at the conclusion that a thin layer of a compound of chromium is produced on the kathode at a certain kathodic potential, and that this layer acts as a diaphragm and causes the liberation of free hydrogen, whereby the reducing action of the latter is greatly diminished. Various solutions (sodium iodate, sodium iodate and sulphate, potassium nitrate, &c.) were electrolysed, with and without addition of chromate, and the percentage reduction determined by comparing the volume of hydrogen liberated at the kathode with that liberated in a hydrogen voltameter in series. The chromium compound produced at the kathode in solutions which are acid, or which contain an oxidising agent (such as hypochlorite), is considered to be chromic chromate ; in other cases, hydrated chromic oxide. F. G. D.

915. *Polarisation with Alternating Currents.* **F. Oliveri.** (Phys. Zeitschr. 2. pp. 225–227, Jan. 12, 1901.)—If a voltameter be inserted in a circuit carrying an alternating current, then during each half-period one of three conditions must exist in the voltameter : (1) Only small polarisation may be produced ; (2) The polarisation may be almost a maximum ; (3) The electrodes may be saturated and electrolysis take place.

By using a Joubert arrangement of momentary contact for measuring the polarisation, the author, by varying the period of alternation, has experimentally proved the existence of these three conditions and finds that a voltameter, in the case when the polarisation is small, acts like a condenser.

No experimental data are given in this paper, which is itself an Abstract of the original paper (N. Cimento, 12. pp. 141–155, Sept.-Oct., 1900).

J. B. H.

916. *Electrolytic Analysis.* **A. Hollard.** (Écl. Électr. 26. pp. 165–166, Feb. 2, 1901.)—With reference to Ost and Klapproth's experiments on the estimation of antimony, the author remarks that the solution of the deposited metal by the polysulphides formed is only noticed when Classen's capsule is employed, and may be prevented by the use of Luckow's cone or of the electrolytic cell formerly described by the author. Another inconvenience attending the use of sodium sulphide is that small quantities of copper are dissolved by it, and deposited along with the antimony ; this is prevented by adding potassium cyanide. In the presence of tin a large excess of sodium sulphide is necessary. N. L.

917. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 26. pp. 129–131, Jan. 26, 1901.)—In the estimation of antimony by Classen's process the increasing amount of polysulphide lowers the voltage and causes a part of the deposited metal to be redissolved. Ost and Klapproth have sought to remove this defect by the use of a diaphragm. This latter has the form of a basin of porous porcelain which separates the platinum anode from the outer platinum dish which forms the kathode. If the solution of the sulphosalt of antimony containing excess of sodium sulphide is placed in both the anode and kathode compartments, the metal in the latter is completely precipitated, whilst that in the former remains in solution. When the antimony is introduced into the kathode space only, it is entirely removed from the solution, provided the sodium sulphide is sufficiently in excess and the voltage consequently low; if these conditions are not fulfilled, a little antimony sulphide is deposited on the anode. If the metallic solution is placed in the anode compartment only, the metal is not deposited on the kathode, but the sulphide is formed at the anode. From these results it is concluded that the e.m.f. depends almost entirely on the amount of sodium sulphide present; this first undergoes electrolysis, and the deposition of antimony is due to a secondary reaction. Antimony ions take no part in the process, and it is only under certain conditions, as stated above, that it passes through the diaphragm in the form of the complex ion SbS_4. In the electrolysis of sodium sulphide solution alone, hydrogen is evolved at the kathode in theoretical quantity, whilst if antimony is added a portion of the hydrogen is replaced by an equivalent quantity of the metal. Oxygen is formed at the anode, but is at once absorbed by the sodium sulphide with the formation of polysulphide and thiosulphate.

The author also describes the experiments of Kahlenberg [Abstract No. 2070 (1900)] on the electrolytic deposition of metals from non-aqueous solutions, and adds some remarks on the various attempts which have been made to substitute other metals for the costly platinum in electrolytic apparatus.

N. L.

918. *Electrolysis of a Mixture of Copper Sulphate and Sulphuric Acid.* **H. J. S. Sand.** (Phil. Mag. 1. pp. 45–79, Jan., 1901. Paper read before the Physical Society of London.)—This paper forms a valuable addition to our literature, both theoretical and experimental, dealing with the electrolysis of mixtures.

From theoretical considerations we are led to believe that hydrogen will not be given off from an acid solution of copper sulphate until the concentration of the copper has practically fallen to zero at the electrode. Experiment shows that hydrogen is liberated from a not too concentrated acid solution of copper sulphate by comparatively low current densities. It might be supposed that diffusion of the copper sulphate in the liquid would effectually hinder its concentration from going down to zero at the electrode with the rapidity which the experiments require to justify the theory, but in this paper the author shows that this is not the case.

The first part of the paper is theoretical, containing a mathematical deduction of an expression for the concentration at the electrode in a solution of a single salt from which the metal is being deposited under the conditions, (1) that the solution is contained in a cylindrical vessel bounded by the electrode; (2) that no convection currents occur, and (3) that the diffusion of the salt obeys Fick's law and its transport values are constant. The formula obtained can be made the basis of a method for roughly determining diffusion coefficients.

In the case of mixtures, it is possible to arrive at limits for the concentration, and it has been experimentally proved by the author (1) that hydrogen always appears at the electrode in an acid solution of copper sulphate in which no currents of liquid are flowing, between the limits of time calculated for the concentration to fall to zero; and (2) that the time when it appears differs only slightly from that calculated from the following equation—

$$c = c_0 - \frac{1{\cdot}1284}{96540} i(1 - n_c)\sqrt{\frac{t}{K}}$$

where c and c_0 are the concentrations at times t and 0, i being the current density in amperes per sq. cm., n_c being the transport value of the kation Cu in the solution and K being the diffusion coefficient of the salt.

The great part played by convection-currents in determining the ratio of the two constituents given off at the electrode of an acid copper sulphate solution is experimentally proved, effective stirring in one case causing the disappearance of hydrogen where it would otherwise have presented over 60 per cent. of the equivalents carrying the current from the solution to the electrode.

The paper contains many tables of experimental results and a description of several forms of apparatus employed. J. B. H.

919. *Laboratory Electric Furnaces.* **C. L. Norton.** (Elect. World and Engineer, 36. pp. 951–952, Dec. 22, 1900.)—The author gives a useful description of furnaces which he has used for laboratory work and temperatures ranging up to 2,000° C. One of these is made by winding 15 feet of No. 28 B. & S. platinum wire round an ordinary porous pot, as used for batteries. The pot is painted with magnesium carbonate to prevent slagging of the wire. The wire is annealed and crinkled to allow for shrinkage before winding on, and is fixed by coating with a paste of magnesium carbonate. Such a furnace when packed with insulating material requires 3 amperes at 220 volts for a bright red heat. A furnace for higher temperatures can be made with carbon as the conductor. W. R. C.

920. *Electrical Bleaching Apparatus.* **V. Engelhardt.** (Zeitschr. Elektrochem. 7. pp. 390–396, Jan. 3, 1900.) Reply by **F. Oettel.** (Zeitschr. Elektrochem. 7. pp. 449–451, Jan. 31, 1901.) The first paper is a criticism of F. Oettel's paper on the Haas and Oettel apparatus [see Abstract No. 537 (1901)]. Engelhardt finds fault with the manner in which Oettel compares the cost of working, plant, and efficiency of his own apparatus with the one invented by Kellner. The conclusion arrived at is that the Kellner apparatus in every point is superior to the Oettel apparatus. A number of comparative tables are given proving this. The second paper is Oettel's reply to the remarks made in the previous Abstract, in which the author wishes to prove that for the same output of chlorine his apparatus is still cheaper. Reference as to the life of the carbon plates as compared with the platinum-iridium wire gauze electrodes used by Kellner is also made. The effect of various concentrations and current densities is discussed. O. J. S.

921. *Present Position of Electrolytic Refining in U.S.A.* **T. Ulke.** (Elect. Rev. N.Y. 38. p. 85, Jan. 12, and pp. 101–103, Jan. 19, 1901.)—This article deals with the progress made in the electrolytic refining industry in U.S.A. during recent years. The number of electrolytic copper refineries is now

eleven, and the present daily output of these refineries is estimated to be 579 tons. The slimes from the copper refining vats are treated for the extraction of their silver and gold, and are stated to yield 19,400,000 oz. silver and 174,000 oz. gold per annum. The Raritan Copper Refinery at Perth-Amboy is now the largest in the country, and has an output of 150 tons copper per day. At this refinery automatic machinery is used for moulding the anodes, and refining costs have now been reduced to under $8 per ton of anode copper. The parting of doré silver by the Molbuis process is carried on at three works, the largest of them being at Perth-Amboy. The daily output of the three refineries is estimated to be 160,000 oz. silver, and the refining charges do not amount to more than 20–30 cents per 100 oz. doré silver. The electrolytic refining of gold bullion is carried on at one refinery, namely, that of the U.S. mint at Philadelphia. The process used is that of Wohlwill, and the estimated daily output is 1,000 oz. J. B. C. K.

922. *Electrolytic Copper Refining Plant at Anaconda.* (Elect. World and Engineer, 37. pp. 186–187, Feb. 2, 1901.)—Details are given of the Anaconda refining plant. The raw copper comes from the smelters, thirty-two miles distant, in the form of anode plates, testing 99·6 per cent. of purity. The refining is carried out in 1,400 lead-lined vats, each vat measuring $8 \times 5 \times 3\frac{1}{2}$ feet deep, and holding 4,000 litres of copper sulphate solution. This solution is circulated by means of pumps continually through the vats, and is kept warm by means of special heating vats. The success of the electrolytic process largely depends upon maintaining the electrolyte in proper condition and at a definite strength. This is checked by means of daily chemical tests. The vats are run in series of 200, the positive bus-bars of one vat being continued as negative bus-bars over the next vat in the series. Each vat contains 19 sets of anode plates and 20 sets of kathode plates, and requires an e.m.f. of 0·3 volt for a current of 4,000 amperes. The current density equals 13 amperes per square foot of anode area, and 210 lbs. copper are deposited per day of 24 hours. The electrodes are placed 2 inches apart, and the vat when charged contains 8,200 lbs. of anode copper. The anodes are renewed every 34 days. The kathode sheets are made by depositing copper electrolytically upon copper sheets coated with graphite and paraffin. These sheets at the end of 24 hours are stripped from the backing and used as kathodes in the refining vats. [For details of the generating machinery see Abstract No. 549 (1900).] J. B. C. K.

923. *Electrolytic Separation of the Alkaline Metals from their Molten Chlorides.* **A. Fischer.** (Zeitschr. Elektrochem. 7. pp. 349–354, 1900.)—In this paper the work done by Grabau and Borchers is first referred to and reasons given why the apparatus constructed by these investigators did not altogether give satisfactory results. In order to study the causes preventing good yields, the author first electrolysed a mixture of molten chlorides of potassium and sodium, using the current itself for keeping the electrolyte fused, employing current densities varying from 5 to 10 amperes per sq. cm. No diaphragm or partition was employed, thus enabling the investigator to closely follow the evolution of the chlorine and sodium. The carbon anode and iron kathode were first brought into close contact, and as the surrounding salt melted the distance of the two was increased, thus forming a pool of

well fused electrolyte round the electrodes. The manner in which the two component elements were set free may be seen from the drawing, as indicated by the arrows and dotted lines.

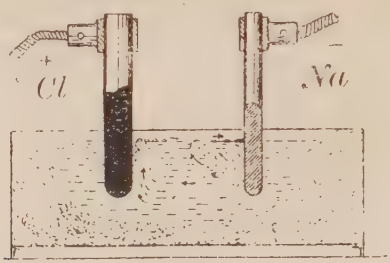


FIG. 1.

Based on these observations the author made a number of differently constructed cells, surrounding the kathode by an inverted metal bell, the immersed edges of which were kept cool by solidified salt, as the result of using a species of water jacket. It was, however, found that this device did not give satisfactory results, as the crust fused or detached itself after a short time, and the metallic bell became part of the kathode, thus interfering with the operation.

The final form of apparatus found to be most suitable is the one shown in the accompanying illustration.

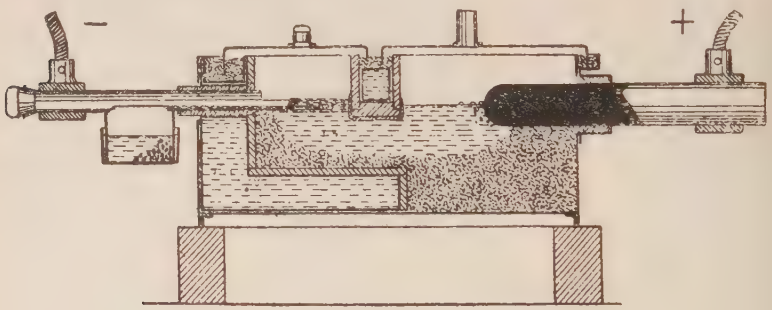


FIG. 2.

The cell consists of a rectangular box, made of sheet iron, having an iron water-jacketed portion in the centre dipping into the electrolyte surrounded by marble for the purpose of exposing no metallic surfaces. The kathodic portion of the apparatus is lined with marble and is water-cooled, which was found to answer the purpose well. The kathode itself consists of a metallic tube just resting horizontally on the surface of the molten electrolyte, thus serving at the same time as an exit pipe for the sodium formed.

Although this form of cell answered well on the whole, it was found that owing to a quantity of liquid sodium, which necessarily must be in the kathode tube, the current density was very much reduced, giving rise to decrease of temperature, and consequently non-fluidity of the electrolyte.

O. J. S.

REFERENCES.

924. *Electrical Energy Direct from Carbon.* **A. E. Kennelly.** (Elect. World and Engineer, 37. pp. 22–24, Jan. 5, 1901.)—A brief review of this subject.

W. R. C.

925. *Significance of Crystalline Form.* **W. F. C. Morsell.** (Frank. Inst., Journ. 150. pp. 441–460, Dec., 1900.)—This paper contains a discussion of the causes underlying the crystalline form of chemical compounds, and does not admit of a satisfactory Abstract. T. H. P

926. *Sterilisation of Water by Ozone.* **Abraham.** (Soc. Int. Élect., Bull. 17. pp. 414–433, Nov., 1900.) -A memoir reviewing the whole subject of water sterilisation, with a detailed description of the development of the various processes and methods of treatment by ozone. The Siemens and Halske, Tindal and Schneller, and Marmier and Abraham ozonisers are described, and the installation of the latter at Emmnerin for treatment of the Lille water supply is particularly dealt with. This has already been noticed [Abstracts Nos. 1755 and 1756 (1899)], but the memoir of the author adds to the previous information by the inclusion of diagrams and plans of the plant and machinery. J. B. C. K.

927. *Osmosis.* **J. Perrin.** (International Physical Congress at Paris, Report, 1. pp. 535–545, 1900.)—This is a short but exceedingly clear presentment of the outlines of our knowledge of this subject. The employment in gases and in liquids of semi-permeable diaphragms, whether natural or artificial, their mode of action as explained by Nernst, their theoretical importance and the part they play in reversible transformations, are all considered. R. E. B.

928. *Mixtures.* **J. D. van der Waals.** (International Physical Congress at Paris, Report, 1. pp. 583–614, 1900.)—This is a *résumé* of the author's theory of mixtures, of the results to which it leads, and of the experimental confirmation it has received. Chief consideration is given to mixtures of normal substances, *i.e.*, of substances the molecules of which are invariable, the report being divided into the following heads :—Homogeneous phases, coexistent phases (the differential equation for which is given and discussed as to its form and results in particular cases), critical phenomena of a mixture, retrograde condensation, critical curves : but a short discussion of mixtures of abnormal substances (of which one of the chief is water) is also given. Some of the ideas expressed in the report (principally in the part relating to mixtures of abnormal substances) are not unassailable ; but the author thinks it proper to indicate points that need examination and not merely to record what is definitely known. R. E. B.

929. *Solubility of Salts in Water.* **R. Dietz, R. Funk, J. v. Wrochem, and F. Mylius.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 425–477, 1900.)—This paper, which does not admit of satisfactory abstraction, contains the results of measurements of the solubility in water of the halogen salts of zinc and cadmium, the nitrates of the zinc-iron group, cadmium sulphate, magnesium and calcium iodates, the sodium salts of chromic acid and calcium chromate. The various hydrates formed by each salt are given and solubility tables constructed so as to show (1) the concentration of the saturated solution in parts by weight, (2) the number of molecules of water per molecule of salt, and (3) the number of molecules of salt per 100 molecules of water. The solubility curves for the different hydrates are shown, and in some cases crystallographic data are given. T. H. P.

930. *Standard Cells.* **W. Jaeger.** (Centralblatt f. Accumulatoren- u. Elementenk. 2. pp. 1–4, Jan. 1 ; and pp. 23–24, Jan. 15, 1901.)—These papers conclude a series by the same author dealing with standard cells [see Abstract No. 2044 (1900)]. The author deals with the thermodynamics of the Cadmium cell and of the Clark cell, both when containing hepta- and hexa-hydrates of zinc sulphate, and gives an epitome of E. Cohen's paper on the same subject [Abstract No. 2064 (1900)]. In the concluding paper the author deals with the changes noticed at about 0° C. in the e.m.f. of the Cadmium cell containing a 14·3 per cent. cadmium amalgam [see Abstracts Nos. 181 and 419 (1901)]. J. B. H.

931. *Electrolytic Solution-Pressure.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 35. p. 369, Nov. 2, 1900.)—In reply to F. Krüger's criticisms (Zeitschr. Phys. Chem. 35. pp. 18–22, Oct. 5, 1900) on his paper [see Abstract No. 254 (1900)], the author points out that these are partly based on a misunderstanding caused by a misprint, and adheres to his conception of the meaning of Nernst's theory. F. G. D.

932. *Fusion and Crystallisation.* **B. Weinberg.** (International Physical Congress at Paris, Report, 1. pp. 449–463, 1900.)—A *résumé* of Tammann's researches and conclusions on phenomena of fusion and crystallisation, and their bearing on the alleged continuity of the liquid and solid states. [See Abstracts Nos. 1 and 1263 (1898); 145, 326, 1111, 1150, and 1693 (1899); 1042 and 1659 (1900); 73 (1901).] N. L.

933. *Crystallisation at Constant Temperature.* **J. H. van't Hoff.** (International Physical Congress at Paris, Report, 1. pp. 464–477, 1900.)—A summary of researches already published on the crystallisation of saline solutions and the theory of the formation of maritime salt deposits. [See Abstracts Nos. 1939 (1899); 226, 1114, and 1879 (1900).] N. L.

934. *Electro-chemical Equivalents of Silver, Copper, and Water.* **A. Leduc.** (International Physical Congress at Paris, Report, 2. pp. 440–459, 1900.)—The author discusses the results of the measurement of these quantities by different investigators, and in the case of silver, the influence exerted by the temperature, concentration of solution, &c., on the result. T. H. P.

935. *On some of the less well-known Carbides, Borides, and Silicides.* **R. S. Hutton.** (Electro-Chemist, 1. pp. 4–6, Jan., 1901.)—A general review of the subject. W. G. M.

936. *Vapour-Pressure of Binary Mixtures.* **P. Kohnstamm.** (Zeitschr. Phys. Chem. 36. pp. 41–62, Jan. 22, 1901.)—Recent views on the vapour-pressures of binary mixtures are discussed in the light of the theory of van der Waals, for whom the author claims not only priority in the discovery of the character of vapour-pressure curves, but also an avoidance of errors into which his successors, who seem to be ignorant of his work, have fallen. As regards the former point he shows that certain results found by others for dilute solutions are obtainable in certain ways from van der Waals' more general formulæ, and he exhibits the divergence of these results from each other and from the truth as arising from differences in their underlying assumptions and consequently in their differing conditions of validity. Some of Ostwald's assumptions and some of the reasoning founded upon them are finally submitted to adverse criticism. R. E. B.

937. *Equilibrium of Chemical Systems.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 21–65, Jan., 1901.)—This article is a translation of the more important parts of a thesis presented to the Faculty of Sciences of Bordeaux in April, 1900. It is divided into three chapters. In chapter I., entitled The Equilibrium of Heterogeneous Systems, the author, following Gibbs and Duhem, investigates and establishes the phase-law of Gibbs. In chapter II., entitled Indifferent Points, the author extends Duhem's theory to multivariant systems (an "indifferent point" occurs when the masses of the independent components are so chosen that the system behaves like a univariant system, *i.e.*, has one degree of internal freedom). In the third and last chapter, entitled The Displacement of Equilibrium, the investigation proceeds on the lines laid down by Planck, and the theorems associated with the names of Clapeyron, Gibbs and Konowalow, Le Châtelier, and van't Hoff are deduced. The paper cannot fail to be of interest to those who are desirous of studying the writings of Gibbs, Duhem, and Planck, even though it contains little that is essentially new. F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

938. *Results of Superheating on the "Inchdune" and "Inchmarlo."* (Engineering, 71. p. 9, Jan. 4 ; and pp. 71–74, Jan. 18, 1901.)—The interest attending this plant lies in the use of superheated steam, and the extremely economical results obtained. The steam was superheated to a temperature approaching 500° F., and the coal consumption was only 0·97 lb. per i.h.p. per hour, or one ton of cargo was carried one nautical mile for about one-third of an ounce of coal.

The engine is of the five-cylinder quadruple expansion type, with all cylinders jacketed except the h.p. Boilers are single ended ordinary Scotch type, to carry 267 lbs. per square in. In the uptake is fitted the superheater, which consists of nests of wavy tubes, the steam entering at the top and leaving at the bottom. The furnace gases, after passing through the superheater, also pass through an air heater, where they are used to heat the air passing to the furnace on Ellis and Eaves' forced draught principle. The feed water is heated by two feed heaters and purified by two feed filters, great care being taken to eliminate all air from the feed water. The feed enters the boiler at temperatures varying between 310° F. and 370° F., and the funnel gases were cooled down to 319° F. in the fan. L. S. R.

GAS AND OIL ENGINES.

939. *New Principle in Gas Engine Design.* **C. E. Sargent.** (Mech. Eng. 6. pp. 857–860, 1900 ; and 7. pp. 29–32, Jan. 5, 1901. Paper read before the American Society of Mechanical Engineers, N.Y., Dec., 1900.) — The disadvantages of the modern gas engine, working on the Beau de Rochas or Otto cycle, are first considered. In a single-acting cylinder, only one impulse being obtained for every two revolutions of the crank-shaft, the working parts must be as heavy and strong for the three other strokes as for the working one, and the engine four times as heavy per h.p. as with an impulse every stroke. In order to improve the regulation of speed two or more cylinders are used. With a hit-and-miss governor there is good economy, because the compression is uniform, but the angular velocity is always increasing and decreasing. By throttling the admission of the fresh charge, and thus lowering the compression and the mean effective pressure, better regulation is obtained at the expense of the thermal efficiency. The high pressure and temperature when the exhaust valve opens are sources of loss. In a 125-h.p. engine a terminal pressure of 40 lbs. to 50 lbs. (absolute) requires a lifting force of more than a ton to open the exhaust valve, and mufflers are needed to deaden the "bark" of the exhaust. The loss of heat to the water jacket depends on the ratio of the volume of the explosive mixture to the surface which confines it, on the piston speed, and on the average temperature of the burning gases. The lower the terminal temperature, other things being equal, the lower the mean temperature, and less heat will be lost to the water jacket and exhaust. The smaller the cooling surface of cylinder walls, and the higher the speed of piston, the less heat will go into the water jacket and more into work. High speed of piston is essential for economy.

The prime object in the new design is to get more complete expansion of

the gases during the working stroke, and the essential feature is to cut off the admission of the fresh charge about mid-stroke, or earlier when governing.

Fig. 1 is an indicator diagram taken from one end of a cylinder of the engine, and Fig. 2 a light spring diagram taken at the same time; *a b* is the atmospheric line, and represents the length of stroke. During the travel of the piston from *a* towards *b*, the fresh charge of gas and air is admitted to *e*,

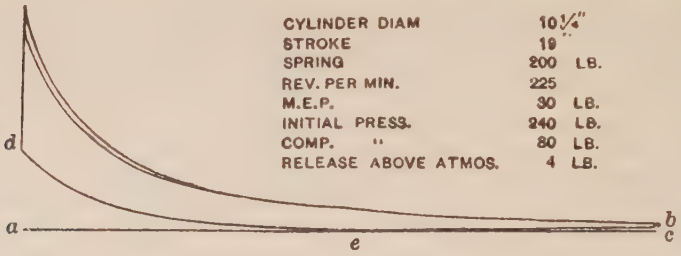


FIG. 1.

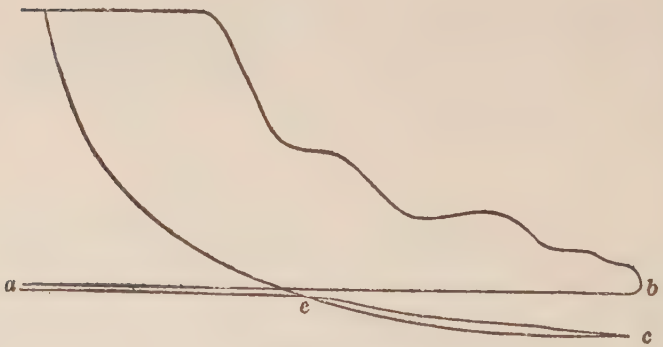


FIG. 2.

Spring 120 lb. Diagram during 5 seconds for varying load.

FIG. 3.

when the admission is cut off and the pressure drops to *c* at the end of the stroke. There is no loss in rarefying the fresh charge from *e* to *c*, since the work is given back to the piston as it returns; and compression above the atmosphere begins at *e* and continues to *d*, the point of ignition. Expansion takes place to *b* when the exhaust valve opens, and the pressure is slightly above atmospheric.

If the highest compression permissible at full power is obtained with cut-

off at mid-stroke, then by making the governor cut off the admission earlier, and also ignite earlier as the speed increases, the pressure is always greatest at the beginning of the stroke (Fig. 3), and the efficiency for light loads should be higher than is usually obtained by throttling the charge, as there is no loss by wire-drawing or by late ignitions. The advantages claimed over the ordinary gas engine are :—(1) At full load 20 to 25 per cent. more heat is turned into work for the same amount of fuel. (2) A noiseless exhaust, doing away with mufflers (silencers), whilst the reduced pressure on the exhaust valve takes a great strain off the side-shaft in opening it. (3) The average temperature of the cylinder is reduced, avoiding premature ignition, and making possible the use of the piston-rod running through water-jacketed stuffing boxes in double-acting tandem cylinders. Therefore, an impulse is obtained every stroke as well as compression to absorb the inertia of the moving parts. (4) Regulation of speed equal to that of the steam engine. (5) For starting, by moving a lever, the valve mechanism can be changed to have ignition at the point of admission closure or cut-off *e* ; and the exhaust opens at the end of the stroke *b*, and remains open during the back stroke of the piston. The same Lenoir cycle takes place at the other end of the cylinder. Otherwise compressed air could be used to get up speed, with a fixed cut-off at half stroke.

Description of Engine.—Side elevations and vertical sections are given of a 75-h.p. horizontal engine, with two double-acting tandem cylinders. The frame is of the self-oiling enclosed type, keeping the oil in and dust out, with bored guides and side-doors, giving access to crosshead and stuffing box. The side-shaft is driven by worm gears at half the speed of crank-shaft. The valve cams and electric igniters, one for each of the four explosion chambers, are keyed to this shaft, 90° apart, so that one end of one cylinder is always giving an impulse stroke, while the three other ends are exhausting, compressing, or drawing in a fresh charge respectively. The worm gears driving the cam-shaft run in a tight-fitting case, into which the oil flows from the basin under the crank-shaft, and is carried up in the spaces between the teeth, and is forced by this ideal pump through a system of circulating pipes to the different sight-feed oilers to the engine bearings. The oil flows by gravity through the strainer back to the settling chamber in the crank case basin. The electric igniter is so placed in each cylinder that a combustible mixture, free from exhaust, always surrounds it, insuring proper ignition of the fresh charge, even at atmospheric pressure.

When the speed goes above the normal, the governor gear makes the cut-off earlier, and less gas and air are admitted to the cylinder ; also the time of every other operation controlled by the cams is advanced.

As the mean effective pressure of an engine utilising only about two-fifths of a cylinder full of combustible mixture for the average load is about 60 per cent. of that of the ordinary gas engine, the cylinder capacity of this engine with greater expansion must be nearly twice that of the ordinary gas engine cylinder for the same power developed ; yet the same could be said of a steam engine utilising the expansion of the steam compared to one without cut-off. The weight for a given output is reduced by the double-acting cylinders, and the engine may be worked with a greater variation of load than the single-acting engine without much loss in efficiency. With a fixed point of ignition and a slower inflammation as the load decreases, a limit to the piston-speed is reached, about 600 feet per minute ; whereas by making the point of ignition earlier in this engine, the piston-speed is 700 feet per minute.

W. R.

940. *Test of Diesel Motor.* (Automotor Journal, 4. pp. 593–596, 1900. Paper read before the Congrès de Mécanique Appliquée, Paris, 1900, by **Diesel.**)—The paper describes the principle and working of the Diesel motor [Abstract No. 974 (1898)], and gives the following figures of a test at full load, when supplied with Russian naphtha and Roumanian petroleum, both rated at 10,000 calories per kilo; the motor showed a consumption of 208 grammes per b.h.p. hour, with a thermal efficiency of 43·6 per cent. The efficiency reached 52·8 per cent. at 6·8 b.h.p. by reason of the excess of air, the combustion curve being then nearer the isothermal. With illuminating gas of 5,000 calories per cubic metre, the thermal efficiency was 36 per cent., and the consumption 470 litres per b.h.p. hour. The thermal efficiency of the Diesel motor is about double that of the ordinary oil engine, but its mechanical efficiency is low, being from 70–75 per cent. Ten indicator diagrams are given in the paper. G. H. B.

AUTOMOBILISM.[1]

941. *Automobilism.* (Automotor Journal, 4. pp. 596–598, Sept., 1900. Paper read at the Congrès de Mécanique Appliquée, Paris, 1900, by **Rochet, Cuenot,** and **Mesnager.**)—The paper is divided into three sections:—(1) Tractive efforts. (2) Existing motors. (3) Gearing, steering, &c. The tractive resistances are: (*a*) Road resistance, varying with the state of the road, the width and nature of tyres, and the diameter of the driving wheels. (*b*) Friction of the journals, which depends on the ratio between the diameters of the wheel and its journal, and also on a friction coefficient, varying with the lubricant. (*c*) Air resistance, calculated from the empirical formula,

$$\text{Resistance} = 0{\cdot}005V^2S \text{ kg. per sq. m.},$$

where V is the speed in km. per hour and S is the cross-section of car in sq. m. The total tractive effort in kg. per kg. weight is given as

$$0{\cdot}033 + 0{\cdot}0006V \text{ with solid tyres,}$$
$$0{\cdot}025 + 0{\cdot}0004V \text{ with pneumatic tyres.}$$

Assuming that the mean gradient on an average run is 1 per cent., the tractive effort necessary to drive a ton at a speed of 10 km. per hour is 1·82 b.h.p. with solid tyres and 1·45 with pneumatic tyres.

A table is given of the different kinds of boilers used in steam vehicles, for solid and liquid fuel, showing the working pressure, the diameter of tubes, the heating surface, the weight, and the consumption. The steam engines are generally made compound above 15 b.h.p. The steam is usually superheated; its temperature in the Serpollet boilers is from 350° to 400° C., at pressures up to 255 lbs. per square inch. The speed of the motor varies from 300 to 800 r.p.m. The total efficiency in power available on the shaft is only about 6 per cent. of the calorific power of the fuel.

For oil engines the effective output is from 0·21 to 0·25 of the theoretical calorific power. Tables are given for steam and oil engines, showing the weight and consumption of various motors per b.h.p. on the shaft and on the wheel-rim. The description of driving and steering gears is abstracted briefly, and the paper concludes with a table of the distribution of weight in the different parts of steam, oil, and electric cars. G. H. B.

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

942. *Hult's Rotary Steam Engine.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 69–72, Jan. 31, 1901.)—In this motor the piston and the cylinder are both carried, eccentrically to one another in roller bearings, and the contact line between them can be maintained to an exact fit by means of an adjustment. The steam enters through a hollow shaft, and the abutment, which slides in the piston, is kept in contact with the cylinder wall by centrifugal force. Sectional drawings accompany the description, and the means of admitting the steam so as to work expansively is explained. The employment of the motor for automobile work is advocated, and it is stated that the steam consumption is about the same as that of the best reciprocating engines ; a test with a 15-h.p. Hult motor showed a consumption of 17 kg. per effective h.p. hour.

A. G. N.

943. *Musker Steam Waggon.* (Automotor Journal, 5. pp. 161–166, Jan., 1901.) A fully illustrated description of all the mechanism employed upon the first steam lorry made by this firm. [See Abstract No. 902 (1900).])—The machinery is carried upon a separate underframe, which is suspended by spiral springs from, and between, the front and rear axles. A "flash" boiler is automatically supplied with kerosene, with the necessary air and with water, in fixed proportional quantities. A mechanical stoker which serves this purpose consists of a constantly running auxiliary engine, whose speed is automatically varied by the steam pressure generated. It drives a centrifrugal fan, which is geared to a high rate of speed, and two oscillating valveless pumps, which work at half the engine speed ; the ports of the pumps are opened and closed by their oscillating movement. The steam to this engine passes through one or both of two reducing valves, the one of which is set to 100 lbs. per square inch and the other to 50 lbs. per square inch. The lower pressure valve is always open, and allows the engine to run only sufficiently fast to nearly keep steam in the boiler when the waggon is standing. The higher pressure reducing valve is supplied with steam only when an automatically operated throttle valve is open. This throttle valve is normally held open by a spring, but is closed so soon as the boiler pressure reaches a certain limit. In this way the speed of the auxiliary engine is regulated by the boiler pressure and the boiler pressure is automatically kept constant in spite of variations of load on the main engines. Other automatic devices consist of two constant, though adjustable, by-passes, and of one automatically controlled by-pass. The former are placed in the delivery pipes of the oil and the water pumps ; since they allow a certain quantity of the feeds to return to their respective supply tanks, they both admit of relative adjustments, and they ensure a slight excess of proportionate feed as the speed of the pumps increases. The automatic by-pass is placed in the water delivery pipe and it is operated by a brass rod which is enclosed in one of the live-steam pipes. The action of this device is such that, when the temperature of the steam rises, the rod expands and closes the by-pass, thereby causing more water to enter the boiler and the temperature of the steam to be decreased. The steam generator consists of three concentric tubular coils of solid weldless steel piping ; about 270 feet are employed, and the tubes are $1\frac{1}{16}$ inches diameter outside and $\frac{11}{16}$ inch inside. The coils are enclosed in an outside lagging of asbestos and sheet-iron and the ends of the two inner coils, furthest from the burner, are stopped with asbestos. The burner occupies one end of the generator, and the heat from it passes into the central space inside the coils ; from there it finds its way between the turns of the two inner coils, and it passes out along the inner surface of the outside coil to the exhaust flue. The

water is forced through the outer (or feed heater) coil towards the burner, through the intermediate coil from the burner and through the inner (or super-heating) coil towards the burner ; the connections between coil and coil are all made at the cooler end of the generator. The burner is of cast iron, and consists of a ribbed chamber into which the air is forced, a second chamber into which it passes after being warmed, and into which the oil is delivered, a multitubular nozzle through which the combustible mixture passes and in which a sheet of wire gauze prevents back firing, and a central pipe which passes through the nozzle and which serves for preliminary lighting and for observation. An iron baffle is placed between the burner and the generator proper. For starting the furnace, methylated spirit is used to heat up the burner. The main engines have four vertical single-acting cylinders, 5¼-inch bore by 3-inch stroke. The power is transmitted by toothed gearing to a differential gear on a countershaft, and from the ends of this countershaft to large sprocket wheels on the rear wheels of the wagon, by Renolds' chains. Mushroom valves, operated by four eccentrics, control the passage of steam to and from the cylinders. The eccentrics are carried on a cranked valve-shaft, which slides longitudinally in its bearings, and which enables the cut-off to be varied from ¾ to ¼ in either direction of rotation. A double safety valve, in the steam pipe, is set to a pressure of 500 lbs. per square inch, and a throttle valve is provided under the control of the driver. The capacity of the water and oil pumps are proportioned in the ratio of 15 to 1, by weight. The boiler will evaporate about 17 lbs. of water from and at 212° F. with 1 lb. of ordinary petroleum. The waggon weighs 3½ tons in working order (the tare is under 3 tons), and it will carry a load of 5 tons at a greater speed than 5 miles per hour. The platform is 17 feet long by 6 ft. 6 in. wide. The front wheels are 3 feet in diameter and the rear wheels are 3 ft. 3 in. in diameter ; 5-in. tyres are fitted to all wheels. A. G. N.

944. *Kécheur Petrol Car.* **P. Sarrey.** (Locomotion Automobile, 8. pp. 6–8, Jan. 3, 1901.)—The author describes a light petrol car designed by A. Kécheur. The motor and speed-changing gear are the special features of interest. The motor is of 4 h.p. and has two horizontal cylinders mounted opposite one another, and having pistons coupled to a single-crank enclosed in an aluminium crank case. The cylinders and combustion and valve chambers are air cooled by means of numerous radiating ribs. The cylinder dimensions are 74 mm. bore × 85 mm. stroke ; the diameters of the valves are 26 mm. for admission and 28 mm. for exhaust. A Longuemare carburettor and electric ignition are employed. In the speed-changing gear a spur pinion is mounted at the extremity of the crank-shaft, and in engagement with it is a second pinion mounted on a pin in a drum which may be turned on the engine-shaft to any desired angle, the pinions always remaining in engagement. At certain positions of the drum the satellite pinion engages with other pinions mounted on fixed pins, and these in turn engage with an internal toothed drum on a shaft from which the power is transmitted to the driving axle. In this manner any desired number of speeds (three forward and one reverse in the car illustrated) may be obtained. C. R. D'E.

945. *Lufbéry Motor Car.* **L. Baudry de Saunier.** (Locomotion Automobile, 8. pp. 53–58, Jan. 24, 1901.)—A fully illustrated description of a petrol-driven vehicle in the design of which many interesting departures from ordinary practice have been made. The chief feature is the transmission gear which consists of a three-stepped pulley on the motor shaft, a single

belt for taking the power to a similar pulley on a countershaft, epicyclic gearing inside the countershaft pulley and a clutch on this shaft. With these comparatively few parts no less than five different forward speeds and three in a reverse direction are obtained. The three fastest forward speeds result from changing the belt from one to another position on the stepped pulleys when the driven pulley is made rigid with the countershaft. By the introduction of the epicyclic train between this driven pulley and its shaft a reduction of the relative speed of the latter is brought about; the highest of the three resulting speeds being equal to the lowest of the three previous speeds, five different gear ratios are thus available. For reversing the vehicle the epicyclic train is moved into mesh with an externally toothed wheel instead of one internally toothed. In order to allow of the movement of the belt from one position to another the pulley faces are bevelled off at their edges, a jockey pulley having a wide range of motion is arranged so as to tighten or slacken the belt, and a special striking gear is fitted. The general arrangement of the vehicle consists of a double cylinder water-jacketed vertical motor fixed at the back of the frame, the countershaft above described placed transversely across the frame and forward of the rear-driving wheels, outside chains connecting the countershaft with each driving wheel and the usual steering gear in front. A. G. N.

946. *Gaillardet Automobiles.* (Locomotion Automobile, 8. pp. 38–42, Jan. 17, 1901.)—Either single-cylinder (6 h.p.) motors or double-cylinder (12 h.p.) motors are employed in the construction of the two types of petrol carriages made by Gaillardet. These motors are of the vertical water-cooled type and are fitted with a form of hit-and-miss governor acting upon the exhaust valves. Variations of speed between 600 and 1,600 r.p.m. are provided for, and either electric or tube ignition (or both) is used. The water tank is placed above the motor in order that natural circulation shall take place in the event of the pump failing to act, and fusible plugs are fitted in the cylinders in such a way that they will melt, and stop the motor, if the temperature were to rise above a safe limit. The motor is fixed in the front of the carriage, the power being transmitted from a wide pulley on the crankshaft to either of three pulleys on a countershaft, by a single belt. The countershaft is mounted in bearings which are pivotted about a second countershaft. The three pulleys are placed side by side and are all of the same size. The central pulley is loose, and those on either side are connected by toothed gearing of different ratios to a differential gear on the second countershaft. A reverse motion is obtained by means of an epicyclic train of wheels contained in the low speed pulley, and it is brought into play by means of a clutch. The precise design of this change-speed mechanism has been carefully considered with a view to the reduction of friction so far as possible; a sectional drawing is given with the description. Drawings of the motors, of the system of governing, and of the complete vehicle also accompany the article. A. G. N.

947. *Schaudel Motor Car.* (Horseless Age, 7. pp. 21–26, Dec. 19, 1900. From La France Automobile.)—This article describes a new French petrol car, the design of which embodies several excellent features. The engine, which is of the two-cylinder horizontal type, is located at the front of an underframe of angle steel filled in with wood, and slightly inclined so as to prevent the lubricating oil in the crank chamber from gaining access too freely to the cylinder bodies and so passing into the combustion chambers. The

power is transmitted from the crank-shaft through a cone friction clutch to a chain gear which drives the first motion shaft of the change-speed gear located immediately in front of the back axle. This change gear is of the usual sliding side-contact spur-gear type, and gives four forward and one reverse speed ; the final drive to the road wheels is by spur pinions engaging with internal toothed drums bolted to the wheel spokes. A feature of this arrangement of transmission gear is that none of the brakes operate through the chain drive, so that the car may be instantly controlled even if the chain should break.

The engine has been unusually well thought out. The two cylinders are placed side by side with pistons coupled to a single crank-shaft so that there is one working stroke every revolution. The cylinder bodies, explosion chambers, valve chambers, and water-jacket are all in one casting, the only detachable part being a cover which closes the end of the water-jacket, which is very simply held in place by two large nuts screwing over the ignition plug bosses at the ends of the explosion chambers. By removing this cover the water jacket may be easily inspected and cleaned out. Both admission and exhaust valves open direct into the explosion chambers, and are suitably proportioned to the volume of the cylinders. All the valves may be removed by releasing one nut which holds down a bridge-piece over the admission valve seatings. The exhaust valves are operated by rocking levers at the end of a longitudinal half-speed shaft which is driven from gear within the crank chamber. The governor is of the centrifugal type and mounted so that it forms part of the exhaust valve operating gear. A spring control to the governor gives a ready means of increasing or reducing the speed of the engine. To secure easy starting an arrangement is employed whereby the admission valves may be held open and the pressure of compression so reduced to any desired extent. Low tension magneto-electric ignition is employed, the magneto and the make-and-brake switches being operated from the half-speed shaft of the engine. The carburettor is a modified form of the usual float feed spray-making type. The steering is by a hand-wheel mounted on an inclined shaft and connected to the road-wheel pivots through a rack and pinion. Most of the controlling levers are mounted on the steering pillar below the hand-wheel. The general lines of the vehicle appear to be excellent, and the heavy parts are mostly at or near the level of the axles. The article is well illustrated. C. R. D'E.

948. *Theoretical Data for High-speed Explosion Motors.* **P. Colardeau.** (Génie Civil, 38. pp. 206–208, Jan. 26, 1901.)—The results obtained from tests made with some of the best-known petrol motors are used for deriving formulæ for the guidance of new manufacturers. These formulæ refer to dimensions of cylinders, powers developed, and to the question of piston speeds. After stating that the power is proportional to the cylinder diameter, the stroke, the number of revolutions per minute, and a coefficient K, the writer proceeds to consider the value of K. It depends on the mean pressure, on the fuel, on the system of cooling, on the arrangement of the valves, and it is not a constant. Curves of power developed and of the accompanying torque for various motor-speeds from zero upwards are plotted out, and these show that for values of Cn—stroke in decimeters $\times \frac{\text{revs. per min.}}{1{,}000}$ (which is equal to a piston speed of 3·33 metres per second)—between 0 and 1 the power developed increases with the speed, the torque remaining constant. For values of Cn between 1 and 1·2 the torque decreases, and the power does not

therefore increase proportionately with the speed, although it does still increase. Above the value 1·2 for Cn, the power itself also decreases rapidly. In these experiments compressions varying between 2·5 and 4·0 kg. per sq. cm. were used, and the mean pressure was found to be sensibly the same. The $\frac{\text{stroke}}{\text{diameter}}$ of the motors tested varied from $\frac{100}{90}$ to $\frac{120}{130}$. In the accompanying table the actual values of Cn and of K (P = horse-power and A = cylinder diam.) are given for various motors; the writer recommends values for Cn of between 1·0 and 1·2, and he considers that K = 4 ought to be a maximum, and should in practice be taken at 3·6 to 3·7.

Motor.	Horse-power.	Number of Cylinders.	Power of each Cylinder.	Cylinder bore in mm.	Stroke in mm.	Revolutions n per minute.	Cn.	$K = \frac{P}{A^2 Cn}$.
Benz	5·25	1	5·25	150	180	500	0·90	2·60
Daimler Levassor	2·50	2	1·25	72	126	750	0·94	2·62
Peugeot	4·90	2	2·45	84	126	750	0·94	2·70
A. Bollée	6·50	2	3·25	95	160	660	1·05	3·37
Y. 3 *bis* [1]	3·00	1	3·00	90	100	1,050	1·05	3·52
Y. 3 [1]	2·50	1	2·50	84	100	1,000	1·00	3·56
Y. 4 [1]	6·81	1	6·81	30	120	960	1·15	3·62
Y. 1 [1]	7·50	2	3·75	90	120	950	1·14	4·14
Peugeot [2]	6·00	2	3·00	96	132	680	0·89	3·64
Mors [3]	16·00	4	4·00	96	140	725	1·02	4·27
Panhard [4]	12·00	4	3·00	90	130	700	0·91	4·07
A. Bollée [4]	9·50	2	4·75	110	160	660	1·05	3·70
Peugeot [2 5]	3·40	2	1·70	72	108	900	0·97	3·34
Rochet Petit [5] ...	6·00	2	3·00	94	140	720	1·05	3·36
Brouhot [5]	7·00	2	3·50	90	160	650	1·04	4·25
Brouhot [5]	9·00	2	4·50	110	160	650	1·04	3·65
Bardon [5]	7·25	2	3·62	100	100	1,000	1·00	3·62
Pygmée [5]	8·00	2	4·00	110	150	650	0·98	3·40
Panhard [5]	8·00	4	2·00	80	120	700	0·84	3·72

1 Personal experience of author.
2 Concours des fiacres, 1898.
3 Tour de France, 1898.
4 Poids Lourds, 1899 and 1900.
5 Concours de Tourisme, 1900.

The article concludes with a consideration of the various conditions under which these motors have to work when propelling automobiles, and when used with and without change-speed gearing, and with or without governors.

A. G. N.

949. *Létang Change-speed Gear.* (Locomotion Automobile, 8. pp. 9–10, Jan. 3, 1901.)—In this device a toothed wheel upon the motor shaft gears with a similar wheel which is free to revolve upon its own axis. Both wheels are enclosed in a casing which is itself mounted about the motor-shaft, and from which the power is taken at varying speeds. The casing is so shaped that it forms passages for the circulation of a liquid with which it is filled. The normal action of the toothed wheels is to circulate this liquid through one of the passages, and under these free conditions the casing remains stationary. A valve is fitted in this passage, and it can be closed either partly or entirely at

will. When completely shut, the circulation of the liquid is stopped, and the whole apparatus is then compelled to revolve with the motor-shaft. By regulating the degree to which the valve is opened, a progressive clutch action is obtained, and the speed of the casing can be varied from that of the motor to zero. A. G. N.

REFERENCES.

950. *Uniformity of Turning Moment in Steam Engines.* **Lorenz.** (Inst. Naval Architects, Trans. 42. pp. 175–179 ; Discussion, pp. 179–185, 1900.)—The author shows, by methods of harmonic analysis, that the best possible uniformity of turning moment, in a three- or four-crank engine, is not only compatible with the conditions for balancing, but is dependent on them. He gives a method by which, supposing the crank angles already definitely given by conditions for balancing, the necessary distribution of work between the cylinders so as to give the least variation of turning moment may be found. H. R. C.

951. *Balancing of Steam Engines.* **O. Schlick.** (Inst. Naval Architects, Trans. 42. pp. 135–154 ; Discussion, pp. 155–165, 1900.)—The author investigates mathematically the problem of balancing a four-crank engine, taking account of the obliquity of the connecting-rods. H. R. C.

952. *Lentz Engines.* **F. Freytag.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1449–1457, 1900.)—A full description, with several drawings, of the various types of engine manufactured under the Lentz patents by the Brünn Machine Company.

953. *Gehre's Steam Meter.* **L. C. Wolff.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1694–1697, 1900.)—This apparatus is intended to measure the amount of steam passing at any instant along a steam pipe, the amount being automatically recorded on a revolving drum.

954. *French Trials of Alcohol for Automobiles.* (Automotor Journal, 5. p. 173, Jan., 1901.)—See also Reference No. 437 (1901).

GENERAL ELECTRICAL ENGINEERING.

955. *Casting Accumulator Plates.* (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 415–416, Dec. 15, 1900.)—The usual method of pouring the molten lead at 400–600° directly from a ladle into the mould has several objections. These are overcome by the process of E. Levermann (D.R.P. 111,753). The improvement consists in attaching to the mouth of the mould a specially designed enclosed chamber which enables the work of casting to be accelerated. W. W. H. G.

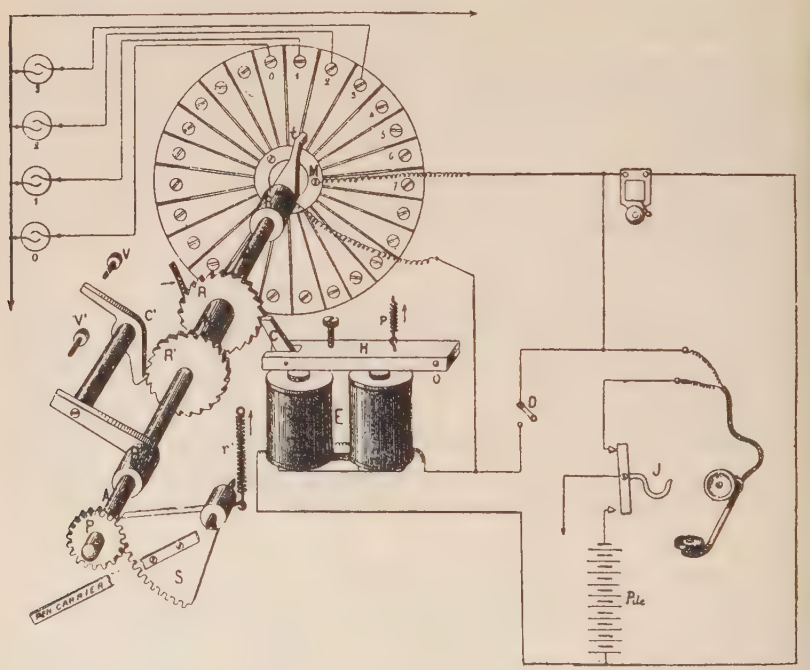
956. *Elastic Materials in Accumulators.* **F. Peters.** (Centralblatt f. Accumulatoren- u. Elementenk. 2. pp. 21–22, Jan. 15, 1901.)—After discussing the various materials that have been employed as separators. the author devotes the remainder of the article to a description of the invention of J. Vaughan-Sherrin (English Patent 16516—1896), in which spirally wound ebonite strips are used. The author has made a number of experiments on a cell, charging and discharging it under various conditions. A capacity of 9 amp.-hours per kilo. of complete cell was obtained. The accumulator is owned by the Accumulator Syndicate, London. W. W. H. G.

957. *Siemens and Halske's Engine-room Telegraph.* **G. Dary.** (Électricien, 21. pp. 49–54, Jan. 26, 1901.)—This apparatus is one in which a rotary field is employed [see Abstract No. 70 (1898) and Revue International d'Électricité, 1892, 2nd sem., p. 435]. Some of the features of the new instruments are : Worm gearing connecting the arbor of the receiver with the pointer, thus preventing oscillation ; the mechanism consisting of a star-wheel and spring-pressed plunger for interrupting the circuit at the transmitter ; and the special form of instrument for steering. In the example described, there is a separate circuit for each diametrically opposite pair of coils in the receiver. C. K. F.

958. *Aluminium Conductors.* **W. Hoopes.** (Street Rly. Rev. 11. pp. 45–46, Jan., 1901.)—The author gives the usual constants for aluminium and copper, the figures for the relative conductivity (equal sectional areas) being 52·9 and 100. As regards the utilisation of aluminium for power transmission, the author states that first cost of the metal is only one factor of the problem of relative cost, and that (1) reliability, (2) durability, and (3) cost of erection, all require to be taken into account before arriving at a final decision. With regard to the first, he states that the breaks which occurred in the early trials of aluminium in U.S.A. are now recognised as having been due to the use of impure metal, and that all wire sold for conducting purposes is now drawn from the purest grade of aluminium manufactured. As regards durability, it is well known that the metal is attacked by hydrochloric acid, chlorine, and caustic alkalies, but even in the case of atmospheres containing these compounds, oxidation of the metal will probably hinder disintegration. With regard to the third point, the cost of erecting aluminium should not be greater than that of erecting copper, for the metal is much lighter, and longer lengths of wire can be handled without difficulty. Fewer joints will

also be required. Two recent orders for aluminium in connection with power schemes in U.S.A. have amounted to 1,000,000 lbs. and 250,000 lbs. respectively. J. B. C. K.

959. *The Pecquet Watchman's Control System.* **L. Montillot.** (Électricien, 20. pp. 371–373, Dec. 15, 1900.)—In this system there is a central control station which is connected by lines to the points at which the watchman has to call. At each of these points the line ends in a spring arranged opposite to another spring connected to earth, so that by inserting a plug bearing two contacts between the springs the watchman can connect the respective lines to earth through an alarm, or through a pair of telephones, as desired. At the central station, each line is connected to one of a series of springs arranged radially on an insulating frame in the order in which the calls are



to be made; these springs normally rest on a central contact piece M, whereby they are connected to earth through an alarm and a battery, or through a telephonic apparatus to earth, as desired. Over the springs there moves a contact-arm *t* which is rigidly mounted on a rotary shaft A and acts to move the radial springs successively out of contact with the central contact piece M; each spring, when in engagement with the arm *t*, connects the line to earth through the coils of an electromagnet E and the battery. The armature H of this electromagnet bears a pawl C acting on a ratchet-wheel R which is rigidly connected by a sleeve N to a second ratchet wheel R^1 having its teeth arranged in the opposite direction and engaging a pawl C^1 mounted on an arm B^1 on the shaft A, so that the shaft will be rotated by the pawl C through an angle corresponding to one spring each time the electro-

magnet E is de-energised. The shaft also bears a pinion P engaging a toothed segmental wheel S having a pen which is in contact with a chart moved by clockwork. It will be seen that, as the watchman inserts his plug between the springs at the several calling points, the circuits will be closed and the armature H displaced to enable the ratchet-wheel R to be turned by the spring P when the circuit is broken on removing the plug. When all the stations have been visited, the pawl C^1 is tripped by the stop V^1, and the shaft A returned to its initial position by the spring r^1, the sleeve N bearing the ratchet-wheels R and R^1 meanwhile remaining stationary. By placing the plug a second time between the springs, the watchman can close the circuit of the bell at the central circuit through the plate M, since the arm B will have been moved on to the spring of the next call point. If the circuit be closed through the switch D, the watchman will hear the ringing on his alarm and thus be advised that he is to speak with the central station.

C. K. F.

960. *Electrical Apparatus in Coal-Mining.* **J. P. Jackson.** (Frank. Instit., Journ. 151. pp. 29–50, Jan., 1901.)—This is a paper broadly covering the ground of the application of electrical apparatus in coal-mining, and is of special interest in that it shows some of the actual difficulties which have occurred in practice under the conditions of installation-making, &c., current in America. It clearly shows that about 250 volts is the maximum safe pressure in mining, as both men and mules have been injured to a considerable extent with 500 volts. Some useful figures and data as to electric haulage by locomotives and the use of electric coal-cutters are given, and the author emphasises the necessity for electric plants being put in charge of persons with electrical knowledge, instead of as usual into the hands of a "bright young miner."

Ll. B. A.

961. *Tests of Electrical Hoists.* (Elect. Rev. 47. pp. 1023–1028, Dec. 28, 1900.)—The hoist tested was constructed to lift one ton at 40 feet per minute. It is driven at 850 revs. by a motor, which drives through steel cut gears, and is capable of taking 25 amperes at 220 volts. The cage, which is balanced by a cast-iron weight, is raised by a 2-inch rope. A complete table of results is given. A more detailed test on a larger lift is also given, and shows an excessive power consumption, which is attributed to over-heating of a worm wheel.

M. O'G.

962. *Winding of Spools.* **F. Claussen.** (Elektrotechn. Zeitschr. 21. p. 1055, 1900.)—In a letter to the editor the formulæ previously given by A. Löwit [Abstract No. 235 (1901)] are discussed and more complete ones proposed, in which the case of rectangular wire is included. The method of calculation is as follows :—

Let $d + \delta$ be the diameter of the covered circular wire, δ being the thickness of the insulation, $d_1 + \delta$ and $d_2 + \delta$ the dimensions of the cross-section of the rectangular wire. Then the areas will respectively be :—

$$q_1 = \frac{\pi}{4}(d + \delta)^2,$$

$$q_1 = (d_1 + \delta)(d_2 + \delta);$$

and if in either case—

$$\frac{q_1}{q} = y = \frac{\text{area of covered wire}}{\text{area of copper}},$$

then the total number, n, of the windings will be :—

$$n = \frac{l}{d_1 + \delta} \cdot \frac{h}{d_2 + \delta} = \frac{lh}{q_1} = \frac{lh}{yq},$$

where l is the length and h the depth of the winding. The resistance of the bobbin for each layer will be :—

$$w = \frac{us}{q},$$

in which u = mean length of a turn and s = the specific resistance of the wire, and the total resistance—

$$W = nw = \frac{lhus}{yq^2}.$$

We have also—

$$W = V/i,$$

V being the terminal voltage and i the current. Or,

$$\frac{V}{i} = \frac{lhus}{yq^2}.$$

The value of q is determined by—

$$q = \frac{Zsu}{V},$$

where Z is the number of ampere turns. For a bobbin of specified inner and outer diameter and with Z given, then hus/yq^2 is a constant, and—

$$V/i = l \,.\, \text{const.} = W,$$

or— $$il = V/\text{const.} = \text{const.}$$

The value of l is next considered. The outer cooling surface is—

$$O = lD_a\pi,$$

D_a being the outer diameter of the winding,

and— $$D_a\pi = u + h\pi\,;$$

hence— $$O = l(u + h\pi).$$

Again— $$O = i^2WZ_1,$$

where Z_1 is the number of square centimetres of surface allowed per watt spent in the coil.

Hence— $$l(u + h\pi) = i^2WZ_1.$$

If— $$\frac{hus}{yq^2} = k,$$

then— $$V/i = W = lk.$$

Hence— $$\frac{u + h\pi}{k} = i^2Z_1,$$

or— $$i = \sqrt{\frac{u + h\pi}{kZ_1}}.$$

These formulæ include the cases that occur in practice. W. W. H. G.

963. *Electric Travelling Crane.* (Mech. Eng. 7. pp. 112–115, Jan. 26, 1901.)—Description with diagrams of a 75-ton, 4-motor, travelling crane constructed by Adamson & Co., of Hyde; longitudinal travel, 80 feet per min., cross travel, 50 feet per min., main hoist, 3 feet per min., auxiliary hoist, 10 feet per min. The efficiency of the hoist is 53 per cent. at 50 tons, and 51 per cent. at the full load of 75 tons. H. R. C.

REFERENCES.

964. *Accumulators at the Paris Exhibition.* **J. Reyval.** (Écl. Électr. 24. pp. 161–173, Aug. 4; 25. pp. 110–112, Oct. 20; 141–143, Oct. 27; 220–225, Nov. 10; 374–380, Dec. 8; **L. Jumau,** pp. 485–488, Dec. 29, 1900.)

965. *Winding of Rheostats.* **P. Girault.** (Ind. Élect. 9. pp. 525–526, Dec. 10, 1900.)—The author considers a circuit consisting of a fixed resistance and an adjustable resistance, acted on by a constant e.m.f., and calculates how the cross-section of the adjustable resistance must vary to maintain the maximum current density constant. He treats the case of a band of resistance material, uniform in thickness but of varying breadth, and finds expressions for the variation of breadth with length, with resistance, and with current. These formulæ are given also when the cooling surface is taken into account. G. H. B.

966. *Lightning Conductors.* **A. della Riccia.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 437–515, Dec., 1900.)—An elaborate paper in which the subject of lightning conductors is discussed from the point of view that lightning is comparable to the oscillatory discharge of a condenser, and in which recent theory of such alternating currents is applied in deciding the forms to be adopted. E. H. B.

967. *Water Turbines.* **A. Luraschi.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 403–436, Dec., 1900.)—A description of various arrangements for regulating the speed of turbines coupled to dynamos either by brakes or governors. H. R. C.

968. *Traction Cells.* **J. Zacharias.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 5–8, 1900.)—A short description of the chief types of accumulators that have been used for electric traction is first given. Then follows a more complete description of the "Monobloc" system of manufacture. W. W. H. G.

969. *Three-Phase Travelling Crane.* (Elect. World and Engineer, 37. pp. 310–311, Feb. 23, 1901.)—A short article describing a crane made by Ganz for the Hungarian State Railway. Drawings are given showing some of the details.

GENERATORS, MOTORS, AND TRANSFORMERS.

970. *Magnetic Flux in Dynamo Air-gaps.* **W. E. Goldsborough.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 25–69, Jan., 1901.)—The author has previously outlined a method for determining the flux in dynamo air-gaps [Abstract No. 909 (1899)]. He now elaborates this method and applies it to find the distribution of the magnetic flux in the air-gaps of a modern two-phase machine. This had previously been found experimentally, and there is a close agreement between the calculated and the observed flux. He begins by taking the case of a single rectangular pole and a flat armature, and assumes that the number of lines of force that connect a point on the armature with a point on the surface of the pole is directly proportional to the magnetic potential difference between the points and inversely proportional to the distance between them, this latter distance being the minimum distance *in air*. The two-dimensional problem is the one considered. The strength of the field at any point on the surface of the armature is then found by integration over the surface of the pole. [A more rigorous mathematical solution has been given by F. W. Carter, see Abstract No. 2101 (1900).] By superposing the magnetic fields due to two opposite poles placed near together, he shows how to get the curve of the surface density of the magnetic flux on the armature, and also gives the curve of the surface density on the poles. He then determines the leakage field between the poles, and by superposing his two results he gets the actual flux distribution over the polar surfaces. The effect of slots in the armature is considered. Mathematical formulæ are then worked out for various simple cases. The concluding half of his paper gives a practical application to a two-phase alternator. N. Kohn and L. S. Arnot had made a complete experimental investigation on the magnetic flux in the air-gap of this dynamo in their thesis for an engineering degree. The author's calculated curves agree closely with the observed curves. The width of the teeth of the armature is 4·1 cm., and the width and depth of the slot are 1·9 cm. and 4·9 cm. respectively. He finds that 82·2 per cent. of the flux that enters the armature enters by the tops of the teeth. The surface density of the flux at the sides of the slots diminishes very rapidly until a point about half-way down the tooth is reached, after which it falls off more slowly. When the bottom of the slot is reached the flux density has diminished until it is only 4·2 per cent. of the density at the top of the tooth. Half-way down the tooth the density is 7·9 per cent. As the flux density changes so rapidly at the corners of the teeth it was exceedingly difficult to get its value accurately by experiment. A. R.

971. *Design of Alternators.* **V. A. Fynn.** (Elect. Rev. 48. pp. 55–56, Jan. 11, 1901.) This is a critical letter on a series of articles by A. Heyland on the designs of large alternators (Elect. Rev., Dec. 7, 14, and 21, 1900.) The difficulty encountered in designing alternators is the production of a machine which for a fixed excitation will give a minimum drop of volts between the terminals as the load on the machine increases. Heyland gives the following advice :—(1) Saturate the poles as highly as possible. (2) Introduce as much resistance as you like at the joints in the field. (3) Reduce the variation of

magnetic leakage from no load to full load. (4) Use closed slots with small iron bridges.

The author assigns the drop of pressure to four principal causes : (1) Demagnetising eddy currents set up by leakage fields either due to armature or field current, or both. (2) Ohmic resistance of armature. (3) Increase in field leakage between no load and full load. (4) Armature self-induction. To minimise armature self-induction the author advises high induction density in the armature slots and in the pole shoes. It is not necessary to have the reluctance of the magnetic circuit high. Such a course produces too costly a machine. W. G. R.

972. *Induction Motors.* **B. A. Behrend.** (Elect. World and Engineer, 36. pp. 676–678 ; 725–726 ; 767–769 ; 802–805 ; 843–845 ; 884–886 ; 920–922 ; 998–1001, 1900.) A valuable series of articles describing the practical theory of the alternating current transformer, taking magnetic leakage into account, and its application to the theory of the induction motor. Some of the novel theoretical points mentioned have been previously discussed by the author in the Elektrotechnische Zeitschrift. The chapters containing experiments on magnetic leakage are entirely new. Neglecting at first the ohmic resistance of the primary, the author defines the leakage factor (σ) by the equation $\sigma = \frac{1}{v_1 v_2} - 1$, where v_1 is the ratio of the magnetising force of the primary that extends into the secondary to the total magnetising force of the primary, and v_2 is the corresponding ratio for the secondary circuit. He then gives and proves the well-known construction for the primary and secondary currents in a leaky transformer. He next tests this construction by experiments on a three-phase motor with its armature at rest, and shows that the extremity of the primary current vector lies approximately on a circle. He proves that the maximum possible power-factor of the primary of a leaky transformer is $\frac{1}{2\sigma + 1}$.

The formulæ for the three-phase motor are next given, and he proves that the starting current of a polyphase motor can never be smaller than the running current unless the motor be started under conditions, such as higher or lower voltage, different from those under load. The relative advantages of open and closed slots are discussed by showing short-circuit characteristics of an armature with the slots opened and closed respectively. He concludes that, if the iron bridges be thin in closed slot motors, then they are in no way inferior to open slot motors. The latter, however, are cheaper to wind.

To find the influence of the air-gap (Δ) upon the leakage factor (σ), a three-phase motor was made with two armatures, one with an air-gap 0·5 mm. and the other with an air-gap 1·5 mm. The following figures were obtained :—

	1st Armature.	2nd Armature.
Δ	0·5 mm.	1·5 mm.
Magnetising current.....	3 amperes	7 amperes
Short-circuit current.....	42 amperes	47·5 amperes
Volts	110 in each phase	110 in each phase
Watts consumed	8,550	9,100

From these data he calculates that in the first case σ is 0·058, and in the second 0·128. This experiment seems to show that the leakage factor is proportional to the magnetising current, and also that the overload that a

motor is able to stand is independent of the air-gap. The air-gap influences merely the strength of the magnetising current, but not the output.

He proves theoretically, and verifies by a series of tests, that σ varies inversely as the pole-pitch (p); hence we may write—

$$\sigma = c\frac{\Delta}{p},$$

where c is a factor depending on the shape and size of slots, &c. It is shown how to wind a motor for different speeds, and the numerous drawbacks of a high frequency are pointed out. The following table illustrates these drawbacks :—

Frequency.	Leakage Factor.	Maximum Power Factor.
25	0·05	0·91
50	0·10	0·83
100	0·20	0·715

The design of a three-phase current motor for 200 h.p. is completely worked out, and also the theoretical data for a single-phase motor. The author emphasises the fact that the loss in the armature of a single-phase motor for the same slip is double that in the armature of a polyphase motor. Tests of a 10-h.p. motor are given which experimentally verify his results.

The author examines the results obtained by running a 200-h.p. three-phase motor as a single-phase motor and finds that in the latter case the output would be 35 per cent. less. In conclusion, various neat polar diagrams are given for the general alternating current transformer. A. R.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

973. *Calculation of Three-Phase Distribution.* **D. Stojsavljević.** (Zeitschr. Elektrotechn., Wien, 19. pp. 32–35, Jan. 20, and pp. 48–51, Jan. 27, 1901.)—The necessary calculations required in dealing with polyphase high-voltage long-distance transmissions are explained by means of an example. It is supposed there is a total demand of 2,350 kw. at five places. The total load to be 75 per cent. for power and 25 per cent. for lighting. The primary voltage is assumed as 10,500 and the power-factor for the motor load 0·7. A line of 27 km. length with 10 per cent. lost watts gives the size of wire at 165 sq. mm. With 100 ∼ and the wires on the posts 100 mm. apart, the self-induction is calculated to be 0·0262 henry. With assumed constants the voltage losses are calculated in the line and transformers. The details of the calculations are given very completely. W. W. H. G.

974. *Electric Power Distribution in Factories.* **W. B. Esson.** (Electrician, 46. pp. 461–464, Jan. 18; and pp. 503–506, Jan. 25, 1901. Paper read before the Civil and Mechanical Engineers' Society.)—This paper deals with the consideration of the conditions under which, in workshops and factories, electrical distribution is preferable to that by shafting. As the result of tests on 100 small engines, working under varying conditions, Bryan Donkin found that the average consumption of steam was 150 lbs. per i.h.p.-hour. Moreover, in cases where machinery is driven by shafting, it has been found that about 45 per cent. of the i.h.p. is available at the machines to drive the tools. In eight factories in America, the average power available was 56 per cent., while at the Baldwin Locomotive Works, it was only 20 per cent. of the i.h.p. of the engines. From tests made in 300 factories in France, the figure has been put at 60 per cent. Taking, then, the most favourable case from the point of view of the shafting-driven plant, it may be said that at full load we get 60 per cent., at half load 43 per cent. of the i.h.p. available at the machine end, and so on. Comparing electrical distribution with these results, and supposing the distribution to be effected without the use of any shafting, the author finds that a saving of 10 per cent. of the i.h.p. may be effected at full load, and at three-quarters, half and quarter loads, the saving is respectively 16, 24, and 38 per cent. of the respective i.h.p. The saving in steam is rather less than this, being possibly, for instance, at three-quarter load about 13 per cent. The money value of the saving realised depends on the cost of fuel. Independently of this, much depends on the disposition of the plant to be driven, and the time during which it is under full load. It must, moreover, be borne in mind that the capital expenditure in the case of electrical distribution is greater than in that of the shafting-driven plant. Various cases are, therefore, considered more in detail, and it is stated that the capital expenditure for generator, switchboard, conductors, motors, and fixing will amount on an average to about £20 per h.p. of the motors installed. An engine is necessary in any case, and may be taken at £3 10s. per i.h.p. The cost of shafting and belting is a very variable quantity, but may be put roughly speaking at about £5 per h.p. Interest and depreciation are put down at £2 per h.p. for electrical distribution, and £1 per h.p. for

mechanical distribution. To make the adoption of electrical distribution desirable, it must be possible in any case to show that at least £1 will be saved per h.p. per annum. Each case must, therefore, be considered on its merits. W. H. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

975. *Southampton Tramway and Lighting Station.* **H. G. Nicholson.** (Electrician, 46. pp. 421–425, Jan. 11, and 496–501, Jan. 25, 1901.)—This power station, which supplies current both for lighting and traction, contains both alternating and direct-current plant. The alternate current is supplied to the outlying suburbs for lighting purposes, and the plant consists of three 120 kw. alternators. The direct-current machines are mostly of small size from 100 kw. downwards; a 300 kw. machine is, however, to be shortly added. The traction switchboard is fed through feeders which pass first through the main low tension switchboard, the two being otherwise quite independent, and in different parts of the station buildings. The smaller machines, originally used for lighting purposes only, generate current at 250 volts, and are therefore joined on the main switchboard so that pairs of them are in series, and thus supply current at 500 volts to the traction switchboard. This pressure is further increased by boosters, which are compound wound, in such wise that the pressure between the feeder bus-bars is about 515 volts at no load, and 550 volts at full load. There is also a tramway battery, and another smaller one for lighting. The tramway battery consists of 236 Tudor cells of 1,900 ampere-hours capacity, when discharging for five hours; it is charged by means of a motor-booster, which adds 140 volts, and makes up to 600 volts, which pressure is required when the cells are nearly fully charged. There are five tramway feeders, ranging in size from 0·3 square inch down to 0·079 square inch. A plan of Southampton is given, showing the points to which the various feeders are run. The trolley wire is No. 00 gauge. Side poles with brackets are mostly used; in some places where the brackets would have to be longer than 20 feet, centre poles are used. The swivelling trolley head is used, the distance from the trolley wire to the centre of the track being in some places as much as 7 ft. 2 in. Under the Bargate a single trolley wire is run, the height of this from the ground being 14·4 feet. An automatic switch is used in connection with this, so that the wire is always dead except when a car is passing through. This is necessary to prevent persons on the top of omnibuses, &c., from getting shocks accidentally. The connections to this switch are shown by a diagram, and the method by which the passage of the car switches the current on and off is described. For the most part the track is double, though about one-eighth is single track, and short lengths consist of interlaced lines. The steepest gradient is 1 in 17, and the sharpest curve has a radius of 40 feet. The rails weigh 86 lbs. to the yard, and were supplied in 45-feet lengths. The groove in the rail is $1\frac{1}{8}$ inches wide, and 1 inch deep. The resistance to traction on these rails taken up an incline of 1 in 88 was 27·2 lbs. per ton, the car reaching a speed of 19·4 miles per hour, and in going round a curve of 50-feet radius, the pull was 110 lbs. per ton. At all the junctions, and on the part of the track leading into the sheds, cut crossings are used, as they give a smoother track than cast steel crossings where variable angles are required.

The article contains full diagrams of the main low tension switchboard, and of the traction switchboard; also a plan of the station buildings, and several photographs. W. H. S.

976. *Beckenham Electricity Works.* (Elect. Rev. 48. pp. 22–25, Jan. 4, 1901.)—This station is worked in conjunction with a dust destructor. The Horsfall destructor is employed, and the products of combustion pass from the furnaces through the boilers, and thence through a dust-catcher to the chimney. Alternating current is supplied to the consumer from substations on the three-wire system. The station is designed on the usual lines, except in so far as the dust destructor is concerned; but no drawings are given showing the arrangements of the flues. W. H. S.

977. *Electrical Equipment of the Manhattan Elevated Railway, N.Y.* (Street Rly. Journ. 17. pp. 1–47, Jan., 1901, and Elect. World and Engineer, 37. pp. 10–14, Jan. 5, and 89–93, Jan. 12, 1901.)—The Manhattan Elevated Railway comprises 75 miles of line with some 200 trains, and carries nearly 200 million passengers a year. The heaviest steam locomotives in use weigh 34,000 lbs. on the drivers, and can pull a train of five loaded cars at 14 to 17 miles per hour. During last year the locomotives consumed 226,924 tons of coal and 535 million gallons of water. In less than two years the gigantic undertaking of electrically equipping the whole system has been suggested, planned, and practically completed. The engines are expected to be in operation by June 1st next.

Buildings.—The main power station (the largest in the world) on the East River is designed for 100,000 h.p., with provision for 50 per cent. future extensions. It is 400 feet long by 204 feet wide, divided longitudinally and almost equally into engine-house and boiler-house, the latter containing a basement, two boiler floors and coal pockets immediately under the roof, the height being 128 feet. A freight elevator is provided to lift horse and coal-cart to top floor in case of accident to the coal-conveying plant. The engine-room is spanned by a 50-ton electric crane. The building contains 6,000 tons of structural steel-work. Excavation of the site began August 27, 1899, and the building was ready for the roof in January, 1901. There are four chimney stacks, each 17 feet inside diameter by 278 feet high, the largest in the country. They were begun July 11, 1900, and finished December 15th. The engine foundations are 40 feet square by 21 feet high. There are seven similar substations each about 100 feet long by 50 feet deep, with four stories, the two upper ones for storage batteries, the first floor for switchboards and static transformers, and the ground floor for rotary converters. A 25-ton crane is provided for the rotaries.

Nine alternative systems were considered by the Engineering Board, and the one adopted comprises three-phase alternators delivering power at 11,000 volts into three-conductor cables, which convey it to step-down transformers in seven substations, where rotary converters receive the three-phase current at 390 volts and give out direct-current at 625 volts for the third-rail. The 11,000-volt cables, weighing 9 lbs. per linear foot and having a diameter of nearly 3 inches, are drawn into vitrified clay ducts laid in cement and surrounded by concrete.

Engines and Boilers.—The main power-house contains eight complete and practically independent units, each consisting of one steam alternator, four batteries of boilers, and auxiliaries. Each chimney stack serves two such units. Coal-conveying plant can unload coal from barges into the bunkers on top floor at the rate of 150 tons per hour. The bunkers, which are three in number, separated by 35 feet of air space, hold a 20-days' supply, viz., 15,000 tons. From the furnaces the ashes pass down chutes to the basement into dump cars hauled by an electric locomotive and tipped on to an ash-pit,

whence a bucket conveyer carries them to storage bins on the river front. There are 64 Babcock boilers of 500 h.p. each, constructed for working at 200 lbs. per square inch, with Roney mechanical stokers capable of burning hard or soft coal, either separately or mixed. These stokers require 90 men only, whereas hand stoking would require 270 men. For every two batteries of boilers there is one Green's Economiser. The four chimney stacks are designed to give the requisite draught naturally; but sixteen Sturtevant blowers, each capable of delivering under the boilers 57,000 cubic feet of air per minute at a pressure of one ounce per square inch, are provided to cope with sudden loads. They are driven by direct-coupled alternating-current motors. Eight triplex single-acting boiler feed pumps are driven by 500-volt direct-current motors. There are eight Allis compound horizontal and vertical cross-compound engines, essentially comprising two compound-engines working at either end of the shaft, the h.p. cylinder being horizontal and 44 inches in diameter, and the low pressure vertical and 88 inches in diameter, stroke 60 inches; the two cranks are set at 135°, and the speed is 75 r.p.m. The condensers are Worthington's, arranged at present for jet condensing, but capable of easy alteration to surface condensing when a satisfactory system of extracting cylinder oil has been found. Condensing water is drawn from the river through a rock tunnel 8 ft. 6 in. wide by 12 ft. 3 in. high. Feed water is taken from a 12-inch connection to the city mains. In an emergency a centrifugal pump can deliver salt water from the river into the boilers, and this is not expected to do much harm. The feed and steam piping is on the ring system. At each engine is a steam reservoir 3 feet in diameter by 2 feet long. Four 300-h.p. Harrisburg exciter engines run at 200 r.p.m., with cylinders 15 inches and 25 inches by 18 inches stroke. All auxiliaries are electrically driven, those required to operate before the main engine can be started being wound for 500 volts direct current, supplied by a special battery. The total number of lights on the Company's buildings is 15,000 incandescent, and 250 arcs, and these are supplied from the sub-stations through a motor-generator for raising the frequency from 25 to 60 cycles per second.

Alternators.—The alternators are the largest in the world, and are of the revolving field fly-wheel type. The fields are keyed to the engine shafts, and weigh 370,000 lbs.; the whole alternator weighs 889,000 lbs., and is 42 feet in height. The normal output of each alternator is 5,000 kw. at 75 r.p.m., *i.e.*, 263 amperes per terminal at 11,000 volts under non-inductive load, with a frequency of 25 cycles per second; each alternator field then requires 225 amperes at 200 volts. If the power factor of the circuit is 90 per cent., the field current will be 15 per cent. more than this. If 263 amperes per terminal at 11,000 volts at 100 per cent. power factor are suddenly thrown off, the rise in voltage is guaranteed not to exceed 6 per cent. with constant speed and field. Under non-inductive load the efficiencies are to be 97 per cent. at 25 per cent. overload, 96·5 per cent, at full load, 95·5 per cent. at $\frac{3}{4}$ load, 94·5 per cent. at $\frac{1}{2}$ load, and 90 per cent. at $\frac{1}{4}$ load. These efficiencies cover the C^2R losses in armature and field coils and the armature iron losses, but not mechanical friction. The machines will give their normal output under non-inductive load for twenty-four hours without exceeding a rise of 35° C. With 50 per cent. overload for two hours the rise is not to exceed 55° C. The field winding consists of one layer of copper strip on edge, with the insulating material cemented in place between turns. To prevent hunting, copper wedges are used with large lips which overhang the bevelled edges of the field poles. The armature consists of bars in slots on the inner face of a

laminated ring, and its insulation is subjected to a puncture test of 25,000 volts alternating for thirty minutes, or 35,000 volts for one second. The field pole tips are bevelled at the edges to produce a field of such form that with a star type of three-phase winding, the e.m.f. wave will be practically a sine wave at no load. The field produced by cross magnetisation with load and magnetic leakage around the conductors will be of such form that the e.m.f. produced thereby in the armature windings will also be practically sine-shaped. As the resultant of this wave and the no-load wave form gives the wave form with load, the full-load wave-form will necessarily be very nearly sine-shaped. There will be four armature slots per phase per pole, thus securing a distribution of the coil which should produce a wave practically free from irregularities, and a wave which is the same within close limits for different loads. By this means the harmonics, which are liable to occur with a winding in which there are but few slots per phase, are avoided together with their possible evil effects in connection with the capacity and self-induction of the very extensive system of cables and transmitting apparatus to which the alternators are to be connected. Another advantage attained by the use of a large number of partially closed slots in the armature core is the possibility of using copper dampers over the pole-tips. If the armature had wide teeth and large open slots, the use of such dampers would obviously cause considerable, if not inadmissible, losses due to eddy currents.

Switch-Gear.—Each of the three-conductor cables from the power-house to the substations is equipped at the power-house end with an oil circuit-breaking switch with a time-limit relay device, so that in case of a short-circuit in the cable the supply of power from the power-house shall be interrupted at the end of a predetermined interval, say three seconds. At the substation end the cable is connected to the bus-bars through a similar oil circuit-breaking switch, but in this instance the automatic device is arranged to open the switch instantly in case of a reversal of the current such as would be caused by a short circuit in the cable. Similar cut-off arrangements are made in the substations. The generator panels of the exciter board control only one pole, the positive main switches being placed with the exciter switches and equaliser switches on pedestals near the machines. The exciter bus-bars are in duplicate, with throw-over switches to each circuit. There will be an emergency arrangement on the main operating gallery for discharging simultaneously the fields of all generators operating in parallel. All cables in the power-house will have fireproof covering of asbestos. The 11,000-volt oil break switches are of the "G. E. Type H," each phase being isolated in a special enclosed brick compartment containing two enclosed brass vessels partially filled with oil below the surface of which the circuit is broken. The switching apparatus is controlled electrically without the intervention of compressed air. The switches are operated by powerful springs which are released and then wound up by electric motors. Signal lamps indicate the integrity of the motor circuits. The motors, and therefore the switches, are in turn controlled by electric circuits, which pass through small switches immediately under the hand of the operator, upon a bench board, the controlling switches being so arranged in conjunction with certain dummy bus-bars and connections as to place at all times before the eye of the operator an accurate diagrammatic representation of the existing connections of alternators, switches, bus-bars, and feeders. The switching apparatus is on two galleries 400 feet long. The pilot diagrams are so drawn that the switch handles apparently open and close the diagrammatic circuit. A motor governor controller is provided for equalising the division of the load between

alternators. A 110-volt storage battery is provided for operating the switchboard motors. Immediately behind the bench boards are instrument panels containing for each machine three ammeters, a voltmeter, a 10,000 kw. watt-meter, and a power-factor indicator. This last instrument will also serve as an automatic signalling device between substations and the power-house. If the voltage delivered by the alternators at the power-house is too low, the substation attendants will attempt to raise it by cutting out the field resistance of the rotary converters, thereby drawing leading currents from the power-house. This will be shown on the power-factor indicators of the alternators, whereupon the operator at the power-house will raise his voltage to meet the requirements of the substations, restoring the power factor to unity. The reverse sequence of operations will occur when the direct-current voltage is too high.

Substations.—The switching apparatus in substations is on the same lines as in the power-house. It has not been finally determined whether the converters will be regularly synchronised on the high-potential side of the step-down transformers by means of the oil-switches or on the low-potential side of the transformers by means of the hand-operated switches. Each rotary converter is supplied by a group of three 550-kw. step-down transformers which have loops brought out from the primary windings for adjustment purposes. The transformers are of the air-cooled type, motor-driven blowers being provided; their guaranteed efficiencies are 97·7 per cent. at 25 per cent. overload, 97 per cent. at ½ load and 95 per cent. at ¼ load. For a 25 per cent. overload run of twenty-four hours, the temperature rise will not exceed 45° C. The rotaries are each capable of delivering 1,500 kw. continuously, and 2,250 kw. for some hours. They run at 250 r.p.m with efficiencies of 96 per cent. at 25 per cent. overload, 95·25 per cent. at ¾ load, 93·5 per cent. at ½, and 89·0 per cent. at ¼ load. The field frame is of cast iron, while the pole-pieces are of laminated steel. The pole faces are bevelled at the edges to permit the use of copper shields, which consist of heavy copper rings around the pole-tips, having lips extending from both edges of the pole toward the centre to prevent hunting. The converters are guaranteed to stand an overload of 100 per cent. without hunting or falling out of step. Their fly-wheel effect is made as small as possible because it tends to force them to act independently of changes in the system. The copper shields on its poles tend to force the converter to promptly follow any changes in the system. A motor generator set is provided for starting up the converters by direct current. The reason for the large size of converter is the value of ground space. The largest substation is 50 by 100 feet by 70 feet high, but they each contain 9,000 kw. of converting apparatus as well as a 3,000 kw.-hour storage battery with the necessary boosters.

Third Rail.—The third rail is of a standard section weighing 100 lbs. per yard and rolled in 60-feet lengths. Investigation having shown that reduction of percentage of carbon and manganese tends to increase the conductivity, the composition was specified to be carbon 0·073 per cent., manganese 0·341 per cent., sulphur 0·073 per cent., phosphorus 0·069 per cent. This gives a rail too soft for ordinary track service, but it has only about eight times the resistance of copper. The third rail has a sectional area of 9·8 square inches, and, where the length between substations does not exceed 6,500 feet, with 6-car trains running on a 15-m.p.h. schedule with one minute headway, the voltage drop will be about 10 per cent. The third rail is insulated with wooden blocks from the sleepers, and is divided into 300-feet lengths, with anchored expansion joints, the lengths being bonded with "protected" bonds

in the bottom flange. Wooden guard strips, 2 inches higher than the third rail, are fixed on either side of it. The 90-lb. track rails and the longitudinal girders of the structure are bonded with 0000 stranded cable, welded to copper terminals which are hydraulically compressed into reamed holes. [See also Abstract No. 584 (1901).] The power required at the third rail will vary between 60,000 h.p. during "rush" hours, and 5,000 h.p. for the "owl" cars, the average being 30,000 h.p. This involves an unusual amount of switching. E. H. C.-H.

978. *Three-wire Tramway at Grenoble.* **E. Legrand.** (Écl. Électr. 26. pp. 124–129, Jan. 26, 1901.)—Forty-three kilometres of line between Grenoble and Chapareillan are worked on a three-wire system, the middle wire being the rails and the outers being two trolley wires carried side by side. The two motors on the cars are thus run in series across the outers at 1,200 volts.

The generating station at Lancey, 12 km. from Grenoble, contains three turbines, each giving 340 h.p. at 325 r.p.m., the water being supplied at a pressure of 45 atmospheres from a fall 450 m. high through a riveted zinc pipe. The tail-race water is measured for purposes of payment by being passed into a cylindrical tank with eighty windows, exactly equal, having their sills in one horizontal line, the outflow from one window being easily measured in a graduated vessel. Each turbine drives, through a Raffard coupling, a six-pole compound-wound dynamo giving 417 amps. at 600 volts, provided with Thury automatic shunt regulator to give constant voltage. As the drops on feeders would ordinarily be very great (150 to 250 volts), boosters are used on each feeder. Each pair of feeders has two series-wound boosters driven by one compound motor. In this way the voltage drop is kept within 60 volts. Each booster has a device at the end of its shaft for automatically short-circuiting the armature if the direction of rotation is reversed; this is to guard against the booster racing backwards as a series motor if the compound-wound motor fails. Each car carries two rubbing contacts of antifriction metal. E. H. C.-H.

979. *Electrical Distribution in Colorado.* **J. R. Cravath.** (Elect. World and Engineer, 37. pp. 115–118, Jan. 19, 1901.)—Notes of some interest on the system of distribution used in the greatest gold-mining camp of America, known as the Cripple Creek District, are given. The district includes two large towns, six smaller towns, a number of large mines, and hundreds of claims in various stages of development Coal is worth at least $6 a ton at the mines, and water is also scarce. The region, therefore, appears well adapted for electrical power transmission. Two electrical companies are working, and a third is about to be formed. The power rates are from 2 to 4 cents per B.T.U. Air compressers, pumps, and hoists furnish the chief load. For hoisting, the type of induction motor always used is regulated by a tram type of controller which introduces resistance into the rotor. This method is found much more satisfactory than the use of auto-converters or reactance-coils in the stator. Of the three plants, one generates power 24 miles away by steam, one has steam plant in the district but is closely identified with the railway which brings the coal, the third uses water power 11 miles away. The first of these is *The Colorado Electric Power Company*, which has its power-house at Cañon City, where coal and water are cheap. The system is three-phase, 20,000 volts, 30 $\sim$. There are two substations which distribute power locally at 500 volts, three-phase. From one of the

substations a 2,500-volt line runs to a distant mine, and a 6,600-volt line from the other substation to supply an electric railway power-house. The area of distribution is about 6 square miles, in which the 500-volt distribution forms a network tied together at many points. In substation No. 1 there are four 200-kw. transformers, one being in reserve, for 20,000–500 volts; there are also four 100-kw. transformers for 500–2,500 volts to supply the distant mines. At No. 2 there are also four 200-kw. transformers for 20,000–500 volts, and four 200-kw. for 20,000–6,600 volts for the electric railway power station, where there are transformers and rotary converters. The transformers are all oil-insulated Westinghouse, excepting four Stanley's and one 100-kw. General Electric make.

The transmission from Cañon City is over a mountainous country, and might have been expected to have been much affected by lightning. This has not been the case. Every five miles a bank of Wurts cylindrical non-arcing metal lightning-arresters are placed 16 in series on each line. They are enclosed in porcelain and fixed inside a box on a pole. Choking coils and a similar bank of arresters are provided at each end of the line. The line is of No. 3 copper wire on Mershon insulators, 6 inches diameter and triple petticoated. These have done good service. The wires are 50 inches apart, two on a cross-arm and one on a pin at the top of the pole. Current is kept on the system 24 hours a day and every day in the year. All repairs and alterations are made with current on the line. The plan adopted in changing the insulators and handling the 20,000-volt line wire is to connect the line which is to be handled with a nail in the pole at a point below where the linesman stands when working. This "jumper" makes a better earth than the linesman's body, and hence he is unharmed.

The loss in the line and transformers is 18 per cent. At the substations are fuses of thin copper wire 23 inches long enclosed in thin rubber tube. These have proved successful circuit-breakers. Facilities are provided for cutting out a transformer and substituting the one in reserve. In case the fuses on one of the transformers blow, the other two legs of the circuit will usually carry the load for a short time until the reserve one can be switched on.

On the 500-volt line, lightning is a much more dreaded enemy. As a means of protection the original plan was to put up a cross-bar on the pole and fix three pins on it for the three-phase wires; then barbed wire was secured by staples directly at each end of the cross-arm and to the pole-top. This resulted in short circuits owing to the copper stretching more than the iron wire, but these were avoided by fixing short brackets on the end of the cross-bars, so as to keep the barbed wires further from the copper.

At the power-house at Cañon City the plant consists of three units, each of 30 $\sim$, three-phase Westinghouse generators direct-connected to Hoover-Owens and Rentschler-Corliss compound condensing engines. The exciters are independently engine-driven. The transformers are four 500 kw. In the secondary circuit the 20,000-volt current is opened by switches with a 4-feet break. Automatic circuit-breakers are used at the time the machines are thrown in parallel, but on account of the sudden fluctuations of the load the circuit-breakers are fastened up after the machines are in circuit and the fuses depended upon. H. H. Wilson, chief engineer, has devised a good method for synchronising.

The La Bella Mill, Water and Power Company.—The generating plant consists of McIntosh and Seymour compound condensing engines direct-coupled to 600-kw. three-phase, 6,600-volt General Electric revolving field generators. There are three units. The high-voltage circuits are taken to

substations in eight towns and transformed to 110 volts on a three-wire system. In one station direct-current arc machines are driven by induction motors.

The Pike's Peak Power Company.—Water-power under a 1,000-feet head will drive four Pelton wheels directly connected to General Electric 400-kw three-phase generators. The transmission will be at 12,000 volts.

W. W. H. G.

980. *Snoqualmie Falls Power Transmission.* (Eng. News, 44. pp. 398–404, 1900.)—The Snoqualmie Falls are in Washington, thirty-five miles from Everett; the river has a flow varying from 1,000 to 10,000 cubic feet per second, and the height of fall is 270 feet. A concrete dam 210 feet long is built across the river, just above the falls; it is always submerged, and raises the level 6 feet at low water. A rudder boom 300 feet long is moored above the intake and extends beyond it; by turning a capstan at the head of the boom the rudders are thrown out and cause the boom to swing out into midstream, so that it serves as a fender to deflect floating logs, &c., from the intake. The intake-bay is double, only one bay being used at present; it is constructed of concrete, and is protected by a horizontal timber grating with 12 inch spaces, and behind this is a grating of flat steel bars on edge. About 300 feet above the falls is a shaft 10 feet × 27 feet, descending 270 feet to the bed of the river below the falls. At the bottom is the power-chamber, 200 feet long, 40 feet wide, and 30 feet high; from this a tunnel 650 feet long forms the tail-race. The penstock is a steel pipe 7½ feet in diameter, which passes through the concrete floor of the intake; the plates are in eight courses, and vary in thickness from ¼ inch to 1 inch. At the bottom of the shaft the penstock connects to a horizontal cylindrical receiver 10 feet in diameter, extending the length of the power-chamber. At four points are 4-feet branches, each with a gate valve, which connect with the horizontal receiver of a water-motor.

The Doble water-motors of 2,500 h.p. each are four in number, each consisting of six tangential jet wheels with two nozzles to each wheel. The nozzle orifice is regulated by the axial motion of a "needle" having parabolic curves running to a point; this, as the needle is moved in or out, gives an annular opening of greater or less width, while always maintaining a smooth jet of water. The needles are regulated by a Lombard governor. The wheel buckets have an ellipsoidal form, with centre rib to split the jet, and the lip of each is notched in the centre to allow the jet to impinge on the rib in the position of greatest efficiency as soon as it strikes the bucket. The wheels are 45 inches in diameter with thirteen buckets, the latter being separately replaceable when worn. The wheels are encased in sheet-steel housings, centrifugal discs on the shafts preventing the escape of water where the shafts pass through the housing; these centrifugal discs are found to be more efficient than the packing-boxes and glands which were first fitted. Separate 75 kw. wheels drive the exciters.

The electrical plant comprises four 1,500-kw. Westinghouse generators of the revolving armature type. They give each a three-phase current of 1,000 amperes per phase at 1,000 volts and 60 periods, running directly coupled to the water-wheel shafts at 300 r.p.m. In the transformer chamber at the head of the shaft the voltage of 1,000 is transformed to 30,000, which is the nominal voltage of transmission. The entire station is operated by two men only. The transmission lines are two—one 32 miles in length to Seattle, of 264 mils. aluminium wire; the other 44 miles in length to Tacoma, of

234 mils. aluminium wire. All the lines were joined in series for an experimental test in transmission, giving a total length of line of 153 miles, starting from and returning to the station; a 1,500-kw. machine was connected at each end, one working as a synchronous motor. The apparent kilowatts required to charge the line were at 22,500 volts 62 kw., at 30,000 volts 112 kw., and at 35,000 volts 180 kw. When the voltages at the beginning of the line were 22,500 and 30,000, those at the end were 24,600 and 32,100 respectively. At a constant voltage of 30,000 the apparent charging power at 50 ∿ was 100 kw., at 55 ∿ 105 kw., at 65 ∿ 115 kw. The following test was made on a non-inductive load consisting of a water resistance on the end of the line; drop of volts from 30,000, 25 per cent.; loss in amperes per phase at 1,000 volts, 11·2 per cent. from 624 amperes; loss in kilowatts 34·2 per cent. from 723. With the substation transformers at Seattle and Tacoma in circuit with open secondaries 193 apparent kw. were required to charge the line, and the drop of volts was from 31,500 to 30,000.

The transformers are thirteen in number, each of 500 kw. at 90 per cent. power factor. They are of the Westinghouse self-cooling, oil-insulated type. The high-tension winding is for 15,000 or 30,000 volts, and each layer is wound in the same direction, so as to diminish the potential between adjacent wires, the wire from the end of each layer being carried across the face of the coil to the starting side. The poles carrying the transmission lines are of cedar, 36 feet high; two cross-arms carry six porcelain insulators for the two circuits which are run on each line; the triangular spacing between the wires is 30 inches. The average length of span is 110 feet on the Seattle line and 150 feet on the Tacoma line, a sag of 15 inches being allowed. Joints are made by the McIntyre sleeve, which is a flattened aluminium tube 9 inches long by $\frac{1}{16}$ inch thick, and of a size sufficient to take the two wires; when the joint is made it is given three complete twists. There are several small substations supplying towns on the line of route; the Seattle substation is equipped with four pairs of 300-kw. and two pairs of 500-kw. transformers, stepping down to 20,000 volts. There are also three step-down transformers supplying current at 350 volts to two rotary transformers, delivering continuous current at 550 volts. The rotaries are brought up to synchronism by a small induction motor. The Tacoma substation has three 500-kw. and two 200-kw. transformers. The power available at different points on the system at full load is as follows, assuming a line loss of 15 per cent.: Energy from water = 100, from water-wheel = 80, from generator = 75, from step-up transformers = 72, to step-down transformers = 61, from step-down transformers = 59, from rotary transformers = 53. The Snoqualmie Falls Power Company does not supply power to small customers, but supplies in bulk to sub-companies in Seattle and Tacoma. The article is illustrated by a full-page plate giving plan and sections of the constructional work and illustrations of the power station and substations. There are also in the text a map, drawings of the water motors, and several photographs. [See further Abstract No. 516 (1899).] G. H. B.

981. *Chicago South Side Electric Railway.* (Tram. Rly. World, 10. pp. 1–8, Jan., 1901.)—This elevated railroad was equipped electrically in 1898, on the Sprague multiple unit system [see Abstract No. 344 (1898)], and the results have been most satisfactory. This paper deals mainly with the generating station, which was completed last May. The cost of generating per unit of net output is 0·225 of a penny, made up of: coal, 0·1375; labour, 0·055; water, 0·0125; various, 0·02. Interest and depreciation are not included.

The boilers are by Babcock and Wilcox, the working pressure being 160 lbs. per square inch. The handling of coal and ashes is done by conveyors. The coal costs 5s. 5d. per ton, and $6\frac{1}{2}$ lbs. of steam are produced, on an average, per lb. of coal. The engines are Allis-Corliss horizontal condensing, running at 80 r.p.m. The smaller engines of 1,200 h.p. are guaranteed not to require more than $13\frac{3}{4}$ lbs. of steam per i.h.p. per hour. The speed is guaranteed not to vary more than 2 per cent., with a change from no load to 50 per cent. above normal or *vice-versâ*. The larger engines are of 2,400 h.p., and each has a fly-wheel 22 feet in diameter, weighing 70 tons, and built up of cast-iron in eight sections. The Westinghouse 625-volt generators are driven direct. Current is supplied to the trains by a third rail. There are battery sub-stations near the ends of the line, three miles from the power station, the batteries being simply connected between feeder and track. W. H. E.

982. *Electric Power Transmission at Butte, Montana, U.S.A.* **J. R. Cravath.** (Elect. World and Engineer, 37. pp. 149–150, Jan. 26, 1901.)—Power is generated on the Big Hole River, 21 miles from Butte, by Leffel horizontal turbines driving four 750 kw., 60-cycle 800-volt three-phase alternators. The pressure is raised to 16,000 volts for the transmission line, and transformed down to 2,200 at Butte. Most of the large motors are of the induction type, but over-excited synchronous motors are also used, and a large amount of power is supplied by a 500-volt rotary converter. The synchronous motors are mostly old 125-cycle single-phase alternators rewound. The lighting circuits were formerly on a single-phase system, and the two-wire feeders are now balanced as well as possible on the three legs of the Y by a plug switchboard. The transmission line is protected against lightning by a barbed wire earthed at every fifth post and at streams; this wire is mounted throughout on glass insulators in order to prevent corrosion. This protection has proved very efficient, although many trees are struck. The turbines are controlled by Lombard governors, and these, with the help of the inertia of the fly-wheel alternators, give excellent voltage regulation, as good as with a first-class steam engine. There are no fuses on the generators or high-tension lines. The average power-factor is 87 per cent. One generator is often run as an over-excited synchronous motor in order to reduce the idle current. [See further Abstract No. 449 (1898).] W. H. E.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

983. *Regulation of Tram Motors.* **K. Sieber.** (Elektrotechn. Zeitschr. 22. pp. 35–38, Jan. 10, 1901.)—Eight different methods of motor control are discussed, and a list of advantages and disadvantages is drawn up for each case. The general conclusions that immediately follow, are: 1. For cars with single motors, series motors regulated with the use of resistances in series are the best. 2. For cars with two motors, series motors with series-parallel control should be used. 3. For cars with more than two motors, series motors should still be used. The motors should be run in parallel and the fields also in parallel. W. W. H. G.

984. *Capacity and Rating of Railway Motors.* **N. W. Storer.** (Street Rly. Journ. 17. pp. 67–70, Jan., 1901.)—The author gives curves for a particular

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

motor showing speed, horse-power, and tractive effort, for different currents, iron loss for different pressures and currents, and two time curves, one showing the time a motor may carry any current above its rated continuous current, with a rise of 20° C. when already running at its average temperature, the other the time it may carry any load with a rise of 75 C. starting cold. From these curves he works out curves showing speed, volts, and current, at each second, for a run of a quarter of a mile in 58·5 seconds from start to stop or an average speed of 14·2 miles per hour. He assumes the rate of acceleration as 1½ miles per hour per second, and the rate of braking as 2 miles per hour per second, rolling friction being 20 lbs. per ton. The speed curve is drawn by first drawing the acceleration line. This acceleration requires a constant current of 68 amperes while the full pressure is on the motors, and the line is continued until it reaches the speed corresponding to this current, and the full voltage. The current is then assumed to have fallen to 50 amperes; the mean acceleration between 68 and 50 amperes is calculated and a line is drawn, from the end of the first, representing this acceleration. This process is continued until the curve reaches the braking line drawn from the point on the axis representing 58·5 seconds. A line is then drawn at an angle corresponding to a decrease of speed of 0·22 miles per hour per second due to rolling friction. This line represents the time of coasting, and it cuts the acceleration and braking line at such points that the average speed is 14·2 miles per hour. The average copper loss is proportional to the average of the squares of currents during successive intervals. The current which, when flowing continuously, will give the same heating effect, is the square root of the mean square current. This in the example taken is 33 amperes. The iron loss is calculated for each second and the average taken, which comes to 350 watts. Therefore, to reproduce the heating conditions of this service in a shop test, all that is necessary is to run the motors at 33 amperes and at such a voltage as gives, with 33 amperes, an iron loss of 350 watts. It is not necessary to go into the refinements of iron loss to the extent that is done in this analysis. The average voltage on the motor is usually below 250, so an equivalent voltage of 300 may be taken for the continuous test, or 400 for interurban service when the shops are fewer. If the continuous capacity of railway motors is stated in terms of the current at 300 and 400 volts, it covers all classes of service with the necessary precision. The author criticises Lundie's method of rating (Abstract No. 301 (1901).)

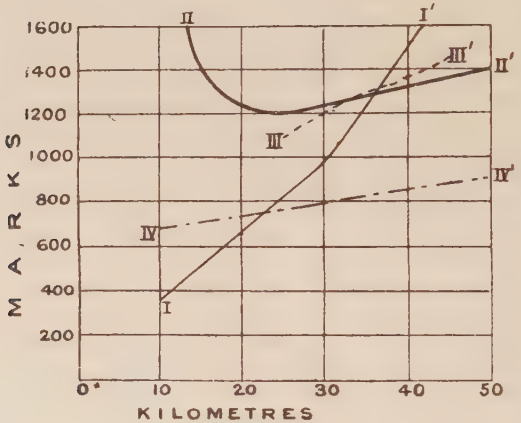
R. B. R.

985. *Rating of Tramway Motors.* **M. Müller.** (Elektrotechn. Zeitschr. 22. pp. 73–75, Jan. 24, 1901.)—Tramway motors are generally rated according to the number of h.p. they transmit. Horse-power may be looked upon as the product of pull and speed. The pull to be developed depends on the weight of the car and other considerations, and the speed is largely governed by the time-table. Both factors are therefore of importance in tramway work. Theoretically it is possible by means of gearing to change a motor giving small torque at high speed into one giving a larger torque at lower speed; but practically, owing to the peculiar construction of tramway motors, and to the small amount of space available, no such change is feasible. A further difficulty arises from the fact that one and the same motor may be described as a 5, 10, 15, or 20-h.p. motor; the ratings depending on differing hypotheses as to the length of time under load, and the permissible rise of temperature. Since there are no conventions on the subject, manufacturers differ widely among themselves. The author suggests that a rating such as 100/15 might be taken

to denote a motor that gives a pull of 100 kg., and a car speed of 15 km. per hour, it being understood that the voltage is 500, the wheel diameter 30 inches, and that the motor will not have more than a certain temperature rise if run for a certain time at full load. With regard to the amount of temperature rise, and the time of loading, these must be matters of convention. The American practice seems to be to rate their motors at the number of h.p. which they can give out for one hour without rising in temperature beyond a certain limit; and this limit is determined by the fact that mica insulation can stand a temperature of 100° C. without sustaining any damage. Therefore for Northern Europe, the rise in temperature may be fixed at about 75° C. It is, however, difficult to say whether the period of one hour is sufficient. The author considers the question mainly from the graphical point of view, and designedly simplifies his calculations by assuming that, within the limits considered, the curves showing the rates of heating and cooling of the motor may be represented by straight lines; and he is of opinion that a period of two hours is more likely to be correct. The following example may be taken as illustrating his method. Suppose the working day to consist of 16 hours, during 8 of which the motor is unloaded; let the permissible rise in temperature be 75° C., and the cooling take place at a mean rate of 28° C. per hour. During the 8 hours, in which the motor is unloaded, it may be considered in all to lose 224°. Seeing that after this cooling it may be still 75° above the temperature of the atmosphere, it may be considered in all to have risen 299°, *i.e.*, at the rate of 37·5° per hour. It would consequently reach the prescribed rise of 75°, if run continuously at full load for two hours. W. H. S.

986. *Methods of Supplying Current to Long Railway Lines.* **G. Rasch.** (Elektrotechn. Zeitschr. 21. pp. 1063–1067, Dec. 20, and 1080–1083, Dec. 27, 1900.)—In dealing with long lines, we may have recourse to one or other of the following systems: (1) Supply from several independent central stations; (2) Supply from one central and one or more substations, the transmission of power from the generators to the substation transformers taking place at a high pressure by means of polyphase currents, which, by the use of rotary converters, are further transformed into continuous currents; (3) Three-phase system of traction, the car-motors being supplied with three-phase current from transformers whose primaries receive power from the generating station at a high pressure. Besides the above three methods, we also have at our disposal the following: (*a*) Use of boosters in feeders supplying the more distant portions of the line; (*b*) The three-wire system; (*c*) Accumulator substations. Considering the last three methods first, the author points out that the use of boosters is only economical in cases where the load on the distant portions of the line is of short duration and occurs at comparatively long intervals. The saving due to the use of a three-wire as compared with a two-wire system does not exceed 20 per cent. under the most favourable conditions, since on account of the fact that the rails have to be used as the middle conductor it is impossible to take full advantage of their high conductance. Accumulator substations, although well adapted for supplying a lighting load, which is of short duration, are not suitable for a traction load, which is spread over a large number of hours. Having dismissed methods (*a*), (*b*), and (*c*) as not being generally applicable, the author next fully discusses and compares methods (1), (2), and (3), assuming certain conditions such as commonly occur in practice. He works out the annual cost per kilometre of power transmission and distribution for the three cases. This

cost includes depreciation and interest on conductors and transforming devices, cost of energy wasted, and in case (1) also the increase in the cost of generating a unit when two or more generating stations are substituted for a single one. The accompanying curves show the results obtained on the assumption of a load of 10 kilowatts per kilometre of track for 17 hours each day. Curve I I′ refers to case (1) with a single generating station; curve II II′ to case (1) with two generating stations; curve III III′ to case (2), and IV IV′ to case (3). It is seen that so long as the length of the line does not exceed 22 km., method (1) with a single station is best. Beyond this limit, the three-phase system is best. A more detailed examination of this system brings out the following important points: (α) the size of the overhead conductor is to be determined by considerations of mechanical strength



and permissible current-density, and not by considerations of economy, the latter always giving sizes which are much too small for practical use; (β) the best size of transformers lies between 12 and 21 kw.: (γ) with a heavily loaded line, the need of an extra high primary pressure makes itself felt beyond a distance of some 35 km. But this extra high pressure can be used advantageously only when generated directly, without the use of step-up transformers. In view of the above results, the author examines the reasons which have caused three-phase traction to be regarded with disfavour: the main reason is undoubtedly due to the necessity of using two overhead conductors, and the resulting complexity in the overhead construction at crossings. A. H.

987. *Methods of Working Long Electric Railway Lines.* **K. Sieber.** (Elektrotechn. Zeitschr. 22. p. 71, Jan. 17, 1901.)—A letter criticising Rasch's paper [see preceding Abstract] on this subject. The author points out that the saving effected by the adoption of a three-wire system may amount to as much as 50 per cent., instead of the 20 per cent. given by Rasch. This is due to the fact that the use of return feeders is imperative, so that in the case of heavily loaded lines the return feeders cost practically as much as the forward ones. The author further criticises Rasch's assumption of a 10-minute service, and thinks that a much more frequent service should have been assumed. A. H.

988. *Electric Railway Traction.* **E. P. Burch.** (Street Rly. Rev. 11. pp. 39–42, Jan., 1901. Paper read before the North-west Railway Club, Jan. 16, 1901.)—After an historical survey of the progress of electric railway traction, the author considers the alterations that are necessitated by the change from steam to electricity. The torque of an electric locomotive is constant, *i.e.*, it does not depend on the inclination of connecting rods, or on varying pressures on the piston. It has, therefore, about 35 per cent. greater tractive force than the steam locomotive, assuming equal weights on the drivers. With the Baltimore and Ohio locomotives, on a dry rail without sand, a tractive coefficient of 30·8 per cent. of the weight on the drivers was found, while with steam the draw-bar pull was 20·6 per cent. Moreover, in the design of electric locomotives, all the weight can be placed on the drivers; heavy steam locomotives for luggage traffic, for instance, lose by having from 10 to 20 per cent. of their weight on the truck wheels. For passenger trains, the dead weight of engine and boiler is greater than is necessary to secure adhesion. On the Empire State Express, the engine and tender weigh 37 per cent. of the total weight of the train. The author considers that with electricity the weight of the locomotive would be so much reduced as to save 25 per cent. of the total weight of the train, and consequently 25 per cent. of the power required. It is claimed that the cost of repairs to track and rolling stock would be much reduced by electric traction. This is due partly to the decreased weight of locomotives, and partly to the absence of unbalanced parts, and the consequent vibration, which acts destructively both on the track and engine. The life of a steam locomotive is put down as being ten years. Stationary boilers and Corliss engines should not cost 10 per cent. of this amount for repairs, and at the end of ten years should not show material depreciation. Further, the cost of fuel should be very considerably diminished. In 1899 it amounted to 9·47 per cent. of the total operating expenses on the railways of the United States. The conditions of working do not allow of any great economy under this head, and the ordinary luggage train requires about 5 lbs. of coal per i.h.p.-hour. A saving of 40 per cent. of the steam might be effected if simple steam locomotives could be replaced by compound condensing ones. The loss in the locomotive is very great, and was found by Goss to amount to 23 per cent. at a speed of 55 miles an hour. Considering the various losses in detail, both on the steam and electric systems, the author considers that half the coal used on existing railways might be saved, which means a saving of 5 per cent. of the total operating expenses.

W. H. S.

989. *Electric* versus *Steam Locomotives.* **W. Langdon.** (Inst. Elect. Engin., Journ. 30. pp. 124–150; Discussion, pp. 150–231, Feb., 1901.)—The cost of locomotive power for the United Kingdom (including stationary engines for pumping, &c.) averages 9·988d. per train mile. The author estimates in detail the cost of working 50 miles of the Midland Company's line between St. Pancras and Bedford, excluding the suburban traffic. From the Block Books it appears that the mechanical h.p. required to operate the trains is 3,890 h.p.-hours per hour, or 2,905 kw.-hours per hour, fourteen trains passing any given point per hour.

The proposed scheme consists of a generating station midway, containing four 2,500 kw. three-phase 10,000 volt generators, feeding substations each serving 10 miles of railway at 600 volts. To supply the above-mentioned 2,905 kw.-hours per hour, the author estimates that 5,000 kw.-hours must be

generated to work the fourteen trains, which travel 479 miles during the hour. For this a generating plant capable of 10,000 kw. is ample, and the prime cost will be—

Generating station, complete	£250,000
Substations	80,000
Cables and laying	70,000
Contact rail (200 miles for the four roads)	70,000
Total capital outlay for generation and distribution	£470,000

The average cost, over twenty-four years, of drivers and firemen was 2·650d. per train mile, and of repairs and renewals in the locomotive department, 2·641d. per train mile. The estimated costs with electric working are—

	Per kw.-hour. Pence.	Per Train Mile. Pence.
Generating charges	0·1574	1·643
Substation charges	0·0299	0·312
Outdoor attendance	0·0041	0·043
Oil, waste, and sundries	0·0109	0·114
Locomotive drivers and assistants	0·2538	2·650
Repairs and renewals of machinery, motors, &c.	0·1916	2·000
Renewal of cables and contact rail	0·0249	0·259
Total cost for power and haulage	0·6726	7·021
Interest at 3½ per cent. on primary outlay, viz., £470,000	0·0901	0·941

This shows a saving of 1·922d. per train mile over steam working. Coal is based on 3·0 lbs. per kw.-hour, or 31·315 lbs. per train mile, as against the 50·191 lbs. consumed per train mile by the average locomotive. The steam figure includes shunting, and the use of less expensive coal in stationary engines would probably make the electric figure also cover it. Expensive coal enhances the comparative value of an electrical system. With steam working, water costs 0·211d. per train mile; with electric, 0·0522d. per train mile.

Discussion (pp. 150–231).—**M. Robinson** considered that four or five direct-current stations would be better than the scheme proposed, and calculated that the capital outlay would be thereby reduced from £470,000 to £273,000, while at the same time there would be a saving of 22 per cent. in running expenses. Above 3,000 h.p. there is little or no economy in increasing the size of station with high-speed engines. With American slow-speed engines economy continues to improve with size. **G. C. Cunningham** has found that on the Central London Railway the quantity of coal consumed in the power-house is 0·5 lb. per ton mile and of power is 70 watt-hours per ton mile. **H. A. Hoy** suggested using travelling generating stations containing high-speed engines and generators charging the third rail direct, and disputed the extra economy of stationary engines, which must always be turning, whereas the locomotive is frequently at rest. **R. E. Crompton** drew attention to the small load-factor of the steam locomotive, as shown by the tables, and attributed the low economy of locomotives to this fact. **G. Forbes** questioned the figure for contact rails, which he calculated would have to be 6·6 square inches in order

to get 10 per cent. drop at the midway point, and would then cost £330,000 instead of the £70,000 mentioned in the paper. **J. S. Raworth** was of opinion that the power-house would have to give over 9,000 kw. instead of the 5,000 kw. given by the author. **F. Hudleston** supported this view with actual figures of power required with steam locomotive. Coal on the Underground Railway works out at ¼ lb. per ton mile, and he doubts whether the superior coal accounts for the whole difference between this figure and the ½ lb. per ton mile on the Central London Railway. **A. A. C. Swinton** pointed out that with frequent generating stations the load-factors would be low. **A. Siemens** considered electric traction practicable only where there are upwards of ten trains per hour. **W. Langdon** in reply claimed that his tractive resistance formula was true, at any rate for passenger trains, and that his figure of 3·0 lbs. of coal per kw.-hour was higher than has been obtained on the Chicago and Boston Railways. Polyphase systems seem unsuitable on account of the two contact rails necessary and of the speed-rigidity. E. H. C.-H.

990. *Distribution Systems for Tramways.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 94–109; Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 49–56, and 159–170.)—Report of **Van Vloten** (Brussels) on the replies received from various Tramway Companies to whom a question on the above subject had been put (see *Questionnaire*).

A. *Continuous-Current Distribution.*—(1) Distribution at 550–600 volts, with feeders and return mains; single generating station. This system, so suitable for urban lines, is not to be recommended for lines extending beyond 10 kilometres from the station. Its advantages are: Low cost of generation, regularity of service, use of continuous-current motors, and absence of danger to life. Its disadvantages are: High cost of distribution for long lines, loss of energy in distribution, and dangers of electrolysis. These defects can be diminished by the use of batteries placed on the line. (2) Same distribution with several generating stations. The advantages of several stations are, compared with the previous case: Reduction in the cost of distribution, and less danger of electrolysis; while the disadvantage lies in the increased cost of generation. This system is not advisable except where waterfalls are available along the route. (3) Same distribution, with boosters. The use of boosters reduces the cost of distribution, and enables distances up to 16 kilometers to be worked with continuous currents. (4) Three-wire distributions, with rails serving as middle wire. This system is very little employed on account of the difficulty of obtaining balance between the two sides. (5) High-tension distribution, with substations reducing to 550–600 volts. This system presents no advantages over polyphase distribution, except in the case of the Thury series distribution, in which a number of generators are connected in series, as are also the converters, on a line at constant current. This system effects considerable economy in copper, and enables distant waterfalls to be utilised, but has many practical disadvantages. (6) Accumulator traction. This is applicable only to level lines with small traffic. Its advantages are: Low first cost, economy in power at the generating station, absence of electrolysis and danger. Its disadvantages are: Waste of power in carrying the accumulators, increased wear of rails, and high cost of energy at the motor terminals, and of battery maintenance. (7) Mixed system. Trolley and Accumulators. This system is applicable to lines extending a greater distance from the generating station than the 15–20 kilometres admissible with accumulators alone. The batteries being

charged in the cars cannot be properly attended to, and are consequently subject to more rapid deterioration.

B. *Distribution by Three-phase Current.*—The author first compares the behaviour of three-phase with continuous-current motors. The former run always at constant speed, and therefore a larger motor is required to give increased power on gradients. The three-phase motor is consequently best adapted to very level lines, as found on main railroads. It has the disadvantage of a very small air-gap, about 1·5 mm., which entails careful supervision of the bearings, while its advantages are: Absence of commutator, simplicity of construction, possibility of supply at high pressure, up to 4,000 volts, and economy in braking the cars, by allowing the motor to give back current to the mains. (1) Systems of direct supply from the trolley wire. The chief advantage of three-phase currents is the use of high pressures, and under this condition the advantages of the system are: Economy in distribution network and working, absence of electrolysis, possibility of using a distant waterfall, or of supplying a long line from one generating station. The disadvantages are: Serious complication in the overhead network due to two trolley wires, necessity of good pressure regulation, unequal loading of the three phases due to the self-induction of the rails, inductive effect on telephone and telegraph circuits, and danger to life. (2) System with transformer substations. This system permits the use of a higher pressure on the supply mains, and a lower pressure on the trolley wires, thus economising in distribution and lessening the difficulty and danger of the trolley construction.

C. *Mixed Systems of Continuous and Three-phase Currents.*—These have the advantages of retaining continuous-current motors and of a single trolley wire, while inductive effects are diminished and batteries can be employed. On the other hand, the rotary transformer substations increase the first cost and the running cost, and lessen the efficiency of the system. The author gives a table of the efficiencies of the various types of generators and transformers, and from it calculates the efficiency of the mixed system when the supply is effected in different ways. He also reproduces Huber's table of the comparative costs of different systems. G. H. B.

991. *Narrow and Standard Gauges for Tramways.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 26–30; Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 37–44 and 143–149.)—The replies received from eleven tramway companies (and given in the *Questionnaire*) form the basis of a report by **Gunderloch** (manager of the "Bergische Kleinbahnen" at Elberfeld), of which the following is an abstract.

The cases in which a gauge of less than 1 metre is employed being very rare, the author confines himself to a comparison of the metre and the standard gauge. (1) The narrow gauge facilitates running on curves of small radius, and gives greater latitude in adapting the track to inequalities of the land. Statistics from sixty-one roads do not, however, show that the narrow gauge has been generally adopted on lines with sharp curves, and the author does not think that the advantage possessed by the narrow gauge in this respect is of itself sufficient to warrant its adoption. The author mentions several methods of permitting a more easy running round curves without resorting to the narrow gauge. (2) The first cost of the narrow gauge track is less than that of the standard gauge; this is more especially the case with lines on virgin ground, and when the track consists of Vignoles rails with metallic sleepers.

In the case of lines laid on existing roads and with girder rails the economy of the narrow gauge is negligible. (3) Lines in communication with standard gauge railways should adopt this gauge in order to admit of the passage of the same rolling stock on both lines; the author enumerates the conditions requisite for this. (4) Narrow gauge does not permit the use of such large motors as does standard gauge. For ordinary services a single motor is admissible on the standard gauge, and this effects an economy in the cost and maintenance of motors and controllers. On the other hand, two motors offer so many advantages that they are usually employed apart from considerations of the gauge. For heavy services, however, where two motors of sufficient power could not be fixed on narrow gauge trucks, the standard gauge has a decided advantage. The narrow gauge again does not permit the use of slow-speed motors mounted on the axle. (5) The arrangement of the motors and other mechanism on narrow gauge trucks is so confined as to render proper access difficult. The motors, too, are more exposed to water splashes from the wheels. (6) Compressed air brakes cannot be fixed on narrow gauge trucks. (7) Standard gauge cars are more stable and their construction is more simple than narrow gauge cars. (8) Collisions with other traffic are more frequent on narrow gauge lines, because drivers of vehicles do not realise how far the cars overhang, and do not therefore keep a sufficient distance off from the track. In conclusion, the author very strongly recommends the universal adoption of standard gauge track.

Discussion.—**De Burlet** (Manager of the Société Nationale Belge des Chemins de fer vicinaux), while agreeing with the report, as far as urban and passenger lines are concerned, considered that the lower first cost of the narrow gauge recommended it for country and goods lines. Such lines, by reason of their small traffic, are commercially possible only if their first cost be kept low. In Belgium, of 103 lines, with a total length of track of 2,500 kilometres, only 3, of a length of 23 kilometres, are of standard gauge. The mean cost per kilometre of the narrow gauge lines is 47,500 francs, while that of the standard gauge is 100,000 francs. The speaker considered that the narrow gauge should always be used, except for a short line, or a line in communication with a main line railroad. **Kessels** mentioned the narrow gauge line at Biella, which is in communication with the main railroad, and stated that the cost of loading and unloading was very small. **Haselmann** (Aix-la-Chapelle) considered that the standard gauge was of advantage only when there was communication with a main railroad, and in certain other special cases. **Trantweiler** (Strassburg) agreed with the report, and thought that the economy of the narrow gauge had been exaggerated; on flat ground, the economy is very small. High-speed, one advantage of electric traction, requires a broad gauge for stability. As regards the transport of goods from a narrow to a broad gauge line, he considered the cost to lie not so much in the handling as in the interest on the value of the rolling stock, which is kept idle during the process. G. H. B.

992. *Electric Traction on the Wansee Railway.* **Bork.** (Elektrotechn. Zeitschr. 22. pp. 70–71, Jan. 17, 1901. Translation in Elect. Engin. Feb. 8, 1901.)—The Railway Department of the German Government is carrying out some experiments on the Wansee Railway in the neighbourhood of Berlin [see Abstract No. 720 (1901)] with a view to collecting facts as to the working of electric traction on railways. The line is a short one, and at present only alternate trains are worked electrically. A maximum speed of 50 km. per hour is reached between stations; the motors are placed direct on the axles

of the front and back carriages, there being nine in all on each carriage. The maximum voltage is 750, and batteries are provided at each end of the line to equalise the load. The line is worked on the third-rail principle, the insulated conductor consisting of ordinary rails, supported on insulators at distances of about 4 metres apart, raised about 32 cm. above the track, and at a distance of 1·5 metres from the centre of the same. It is believed that the cost of electric traction is about 16 per cent. less than that of steam traction; but more exact figures may be shortly expected. The energy used amounts to about 23 watt-hours per ton-kilometre, which is one-third of that consumed in street tramways, this saving being put down mainly to diminished friction on clean rails. W. H. S.

993. *Berlin Electromobile Trials.* (Automotor Journal, 5. pp. 166–167, Jan., 1901.)—Fourteen electric vehicles were tested by Kallmann in April (23–28) last year, and, although the makers' names are not given, the results are here set forth in tabular form. The main points considered were construction, performance, control, prime cost, and maintenance cost. The weights, unloaded, but including battery, vary from 930 to 4,130 kg. The maximum proportion of useful to total weight was found to be 25 per cent. in private cars and 30 per cent. in the vans. The percentage of battery weight to total weight varied from 19 per cent. to 37 per cent. The battery weight per kilowatt hour varied from 55 kg. to 130 kg. Kallmann considers that the battery weight may be taken at 30 per cent. of that of the unloaded vehicle, where 30 km. is run on one charge, but that this figure could be reduced to 25 per cent. with better accumulators. Battery weight to useful load showed a ratio of 0·5 in the best van case, and varied to 1·5 with the van class, and to 3·0 with the private vehicle class. Concerning power, the author considers, from the figures given, that 1 kilowatt per ton of total weight is the average power required for speeds of from 8 to 20 km. per hour. A. G. N.

994. *Charging Station for Electric Automobiles.* **R. A. Fliess.** (Elect. World and Engineer, 37. pp. 5–10, Jan. 5, and 77–81, Jan. 12, 1901.)—These two articles contain a lengthy description of the new premises of the Electric Vehicle Transportation Company of New York. They are designed to accommodate 1,000 44-cell batteries and 500 vehicles, and are at present equipped with 300 vehicles and 500 to 600 batteries. Three-phase current is supplied to the station at 6,300 volts, and is transformed down by four 200-kw. 8-pole rotary converters. The current is delivered to the battery charging switchboards at six different voltages by means of auxiliary storage cells which are inserted in the low tension circuits from the converters, partly as boosters and partly as crushers. The charging of the batteries is entirely regulated by the ammeter, no voltmeters being provided, and as the current through them diminishes they are from time to time shifted on to circuits of higher potential. The station is equipped with an elaborate system of electric cranes for lifting the batteries off their stands, electric transfer trains for conveying them to the vehicles, and hydraulic rams and loading stands actuated by electrically driven pumps for putting them into the vehicles. Full particulars of these are given, as well as of the details of the battery stands, switchboards, and wiring arrangements, and there are a number of illustrations taken from photographs. E. J. W.

995. *Telpherage.* **G. Dary.** (Électricien, 21. pp. 17–21, Jan. 12, 1901.)—After briefly sketching the history of telpherage, the author describes th

systems of aërial and underground telpherage of the Consolidated Telpherage Company. In the former system each waggon is equipped with a separate motor, running, by means of a grooved wheel, upon a carrier cable, which forms the return, and collecting current from an overhead trolley wire. A second wheel serves as a guide, and the motor is maintained in a stable condition by the weight of a skip or truck suspended below the cable, or by that of a block and tackle used for handling the skip. The motor is double or quadruple, and is necessarily waterproof. The speed is about 10 or 12 miles per hour, and the weight carried up to 300 kg. The speed is automatically controlled, as well as the stoppage at a terminus. To carry a load of 65 kg. at 12 miles per hour requires $\frac{1}{3}$ h.p.; at starting $\frac{2}{3}$ h.p. is necessary, and $\frac{1}{2}$ h.p. on curves. The whole weight of a quadruple-motor telpher is 90 kg. The line is carried on wooden trestles 50 m. apart, and can be very quickly and cheaply erected.

The underground system consists of tubes of 0·8 or 0·9 m. diameter, fitted with steel rails, upon which run little trains. Energy is supplied to the motors by a trolley line on an automatic block system. A. H. A.

996. *Automatic Block Signals.* (Railroad Gazette, 33. pp. 41–43, Jan. 18, 1901.)—The manual block system has been in use on the line between Pittsburgh, Fort Wayne, and Chicago, but automatic signals worked by electric motors are now employed. There is but one signal for each track at the entrance of each block section, yet the distant signal indication is provided for. But it differs from other systems in having a three-position semaphore by W. M. Grafton. The signal at the entrance of a section which is occupied by a train stands horizontal as usual; but the signal at the entrance of the next section in the rear, which ordinarily would have two arms, one indicating "all clear" for that section and the other "caution" for the succeeding or occupied section, stands in the diagonal position. If the signal is vertical or "all-clear," this indicates that two sections in advance are clear. Each arm has therefore three positions. It is controlled by the track section immediately in front of it by means of the track circuit in the usual manner for "stop," but for "caution," the control is effected by means of a wire on poles from the section where the train is running. A dynamo furnishes current for all the signals, and there is a storage battery at each signal bridge. The electric motors working the signals are $\frac{1}{12}$ h.p. These operate a vertical rod by means of a toothed gear, the rod actuating the semaphore arm. The rod has a series of teeth engaged by a pinion. In order to permit this rod to move down, after the signal has gone to "stop," without reversal of the motor and its train of gearing some of the teeth on the pinion are removed. When the signal is shifted from "stop" to "caution," the motor is automatically cut out by contacts on the post being separated, and when the train has cleared the next section these contacts are restored electromagnetically, the motor is free to work and the arm comes down to "clear." The description of the mechanism and the various circuits cannot well be condensed. E. O. W.

997. *Webb and Thompson Electric Switch and Signal Apparatus.* (Railroad Gazette, 33. pp. 24–25, Jan. 11, 1901.)—This article describes and illustrates a signal cabin at Crewe fitted with this apparatus. The physical exertion necessary with the manual system is obviated, more attention can be given to train movements, points, and signals, and fewer men are required in the cabin. The levers are in two tiers, the upper being used for switch, and

the lower for signal movements. The levers are in the upper part of the cabin, the interlocking, electric switches, &c., in the lower, where adjustments or repairs can be made without interfering with the work of the signalman. Carbon contacts are used in the electric switches, and have shown little wear although in use over twelve months. In operating a switch lever, a check lock is brought into play, and the complete movement is restrained until the points are properly over and the rails bolted, when a current is returned to the magnet of the check lock, a pawl is withdrawn, and the lever can be pulled to its limit. Cables laid in rough wood trunking and filled in with pitch convey current to motors contained in cast-iron boxes at the points. The covers of the boxes are level with the upper face of the sleepers and ballast. The movement of the motor is transmitted to the switch movement cam-wheel by means of a worm and worm-wheel, clutches being employed to disengage the motor as soon as the switch movement is completed. The motor itself runs free until the current is cut off. Signal-posts and ground disk signals are operated by the magnet movement as adopted in the Timmis automatic electric signalling on the Liverpool Overhead Railway. E. O. W.

ELECTRIC LAMPS AND LIGHTING.

998. *Electric Train-Lighting.* **E. L. Clark.** (West. Electn. 27. pp. 395–396, Dec. 22, 1900.)—After discussing the ruling conditions, the author describes a system which he has devised, comprising a voltage regulator, field-reversing switch, and automatic battery switch. The regulator consists of a centrifugal governor combined with a rheostat in circuit with the field magnet winding of the dynamo. The latter is self-exciting, and therefore an automatic switch is added to reverse the connections of the shunt coils when the direction of rotation of the armature is changed. The armature has two windings, one for charging the battery, the other for feeding the lamps direct; these are controlled by an automatic device consisting of several switches operated by electromagnets. A. H. A.

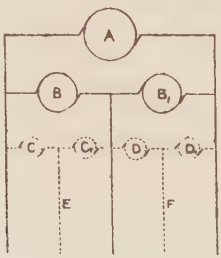
999. *Electric Train-Lighting.* **M. Büttner.** (Elektrotechn. Zeitschr. 22. pp. 17–24; Discussion, pp. 24–29, Jan. 3, 1901. Paper read before the Elektrotechn. Verein, Nov. 27, 1900.)—In this paper, the whole question of lighting railway carriages is discussed. The system of lighting with oil gas in use on the Prussian State Railways is first briefly described, *i.e.*, storing the oil gas in reservoirs under the railway vehicles at a pressure of 6 atmospheres, and connecting the interior of these reservoirs to the burners in the carriages through reducing valves which reduce the pressure to from 25 to 45 mm. of water. Recently 25 to 30 per cent. of acetylene has been added to the oil gas, thus increasing the candle-power (in Hefner candles) of the flames from 5 to about 15. The systems of electric lighting in which dynamos, driven from the axles, work in conjunction with accumulators, are first described. After referring to early experiments, the system of J. Stone & Co., of Deptford, is referred to. In this system, the dynamo is driven by belting from one of the axles, and is switched into and out of circuit with the accumulators and lamps by a centrifugal governor, the belt being arranged so as to slip when a certain speed is exceeded. In Auvert's system, which is used by the *Paris-Lyon Méditerranée Railway Company* the battery supplies current to the lamps and to the field-magnet circuit of the dynamo, the armature of which is automatically switched into circuit when the desired pressure is reached. When the pressure exceeds a predetermined value, a small series motor, having its armature braked, is automatically switched

into circuit, and keeps the pressure at the lamp-terminals constant. In the Moskowitz system, which is used in America, the dynamo field is differentially wound so as to maintain the pressure at the terminals constant at varying speeds. An automatic switch is provided for cutting the dynamo out of and into circuit. The Vicarino system is also referred to. It differs from the Moskowitz system only in the means employed to reverse the poles of the dynamo when the direction of motion of the train is reversed. The Dick system comprises sets of accumulators in each carriage which are charged from a dynamo in one of the vehicles. Methods in which a separate engine and boiler are provided to drive a dynamo in the train are referred to. In one of these, viz., that in use on the Siberian Railway, a De Laval turbine is employed. The author then describes the various systems in which accumulators alone are employed in the trains. In the systems in use on the Danish State Railways, the first and last carriages of a train are each provided with two batteries of 36 cells having a capacity of 120 ampere-hours, the discharging current being 6 amperes, and the charging current 35 amperes. There are two separate circuits in the train, the batteries of one carriage working in parallel on one circuit, and the batteries of the other carriage on the second circuit. The battery boxes are of ebonite, and provided with glass covers. Four of them are mounted together in a wood box, and joined up in series with the end poles connected to contact-bars at the sides. These contact-bars register with contact springs in the separate compartments of a supporting frame, so that the proper connections are made on sliding the boxes into the frame. The arrangements at the charging station are also described. Figures are then given to show that the weight of the installation per carriage is substantially the same as, or even less than, when using oil gas, *e.g.*, using a mixture of oil gas and acetylene, for 5 lights of 15 c.p. burning 27 hours, two gas reservoirs are required, the arrangement weighing 450 to 480 kg. For five 16-c.p. glow-lamps, burning 27 hours, 16 type V-A-55 Hagen cells are employed ; with wood boxes holding 4 cells each and stand, &c., the weight is about 430 kg. The cost of electric lighting is estimated at 0·43 pf. for the Danish State Railways and 0·35 pf. per c.p.-hour (Hefner candle) for the Jura-Simplon Railway. The cost for oil gas amounts to 0·34 pf. per c.p.-hour, and, for a mixture of oil gas and acetylene, to 0·23 pf. The costs of installation per carriage are 700 marks for gas, and 880 marks for electricity. The author advocates, for general purposes, the use of accumulators alone, recharged in the carriages whilst they are idle at the terminus. In the discussion, the electric lighting was rather severely criticised by some of the speakers, one objection given being that assuming the light, cost, and weight of the gas and electric systems to be equal, the gas reservoirs can be re-charged in one minute, whilst the electric accumulators take two hours. Those, however, who spoke in favour of electric lighting, agreed that the most advantageous system was one in which accumulators only were carried in the train, each carriage having its own set. C. K. F.

1000. *Electric Train-Lighting of Railway Carriages.* **E. Dick.** (Elektrotechn. Zeitschr. 22. p. 91, Jan. 24, 1901.)—In this letter a reply is given to M. Büttner and others [see preceding Abstract] who contend that the system in which accumulators alone are used in the carriages is the most advantageous. It is shown that the Dick system, in which a dynamo is carried driven from one of the axles of a carriage (see Schweiz. Bauzeitung, 35, No. 13), is reliable and economical, there being very little wear and tear, and skilled attendance unnecessary. C. K. F.

1001. *Arc-Lamp Standardisation.* **H. Almert.** (West. Electn. 28. p. 88, Feb. 2, 1901. Paper read before the Chicago Elect. Assoc., Jan. 18, 1901.)—The author points out that no practical basis exists for the comparison of the relative values, as light producers, of the different lamps now on the market, and suggests that there should be some definite understanding between manufacturer and user as to what a lamp should and should not do. In arc-light photometry there are many difficulties, the most troublesome of which are the shifting of the arc on the pole-tips, and the difference in colour between the light from the arc and that from the standard. The error due to the first is considerably reduced by the "double-mirror method" of Matthews [see Report of Committee on arc-light photometry of the National Electric Light Association]. It consists simply in taking light simultaneously from opposite sides of the arc by the use of two mirrors suitably adjusted. In addition Matthews uses a rotating sectored disc to reduce to a minimum the error due to colour, but a usual method is to use a series of secondary standards of increasing brightness. In comparing the efficiency of one lamp with another, it must be remembered that it is often the mean intensity of the light in a particular direction, or over a certain portion of a sphere with the lamp as centre, that is to be taken, as the light given out in other directions is wasted, *e.g.*, light given by a street lamp in any direction above the horizontal is for the most part lost. Of the different light standards in use, the author recommends the Reichsanstalt amyl-acetate (or Hefner) lamp as the most satisfactory, though, like the British candle, it is subject to a variation due to atmospheric moisture, amounting, according to Sebenthal, to 8·5 per cent. The paper concludes with an appeal to scientific bodies and institutions to place, within the reach of all, data as to the effect of size and quality of carbons, shades, globes, and globe coatings on the quantity, quality, and distribution of the light produced, and as to the relative efficiencies of the direct and alternating-current arcs, so that it might be possible easily to test the relative merits of different lamps—a feat that the average central-station engineer has no means of performing at present. J. H.

1002. *Arc-Lamps on High-Pressure Supply Systems.* **J. G. Griffin.** (Elect. Rev. 48. pp. 41–42, Jan. 4, 1901.)—An account is given of the difficulties met with in running private arc-lamps on circuits at 200 volts or more. Single



enclosed 220-volt lamps were tried at Burnley after changing over from 105 volts, but failed to give satisfaction. Small balancing wires, E F, were then run, in conjunction with two balancers, CC_1, DD_1, at the station, forming a five-wire system as shown in the diagram, and the old 105-volt lamps were replaced on the 110-volt circuits thus provided, with entirely successful results.

The method of measuring the pressure on the arc-lamp circuits, and an automatic device to give warning if an arc lamp is switched on when the balancers are not running, are also described, with diagrams. A. H. A.

REFERENCES.

1003. *Tractive Resistance of Trains.* **L. Barbillion.** (Écl. Électr. 24. pp. 97–102, 1900.)—A review of the various empirical formulæ. H. R. C.

1004. *Power Station at the Kander Falls.* **H. Rupp.** (Elektrotechn. Zeitschr. 21. pp. 898–905, Nov. 1, 1900.)—A full description of the power station, which supplies energy to the Burgdorf-Thun railway, already referred to in Abstract No. 765 (1900). W. H. S.

1005. *Electricity Supply.* **W. A. Chamen.** (Inst. Elect. Engin., Journ. 30. pp. 105–115; Discussion, pp. 115–122, Dec., 1900.)—An address before the Glasgow Section, dealing mainly with the Board of Trade regulations as to the pressure of supply.

1006. *Alternating* v. *Continuous Current.* (Inst. Elect. Engin., Journ. 30. pp. 3–26, Dec., 1900.)—A discussion as to the advantages and disadvantages of the two systems.

1007. *Berlin Electric Tramways.* **G. Roessler.** (Elektrotechn. Zeitschr. 21. pp. 932–936, Nov. 8; 952–955, Nov. 15; 982–984, Nov. 22; 1001–1003, Nov. 29; and 1019–1023, Dec. 6, 1900. From the Zeitschr. f. Kleinbahnen, Oct., 1900.)—This paper describes in detail the various systems of electric traction in use in Berlin, namely, Surface Contact, Accumulator, and Ordinary Trolley systems. E. K. S.

1008. *Costs of Tramway Construction.* **H. Conradi.** (Tram. Rly. World, 9. pp. 594–598, Dec. 8, 1900.)—This article, which cannot be well abstracted, gives in detail particulars from French tramways of the average costs of—(i) construction of permanent way with various types of rail, (ii) overhead construction on various systems, (iii) underground conduit system, (iv) surface contact system, (v) rolling stock, (vi) steam motors, (vii) compressed air locomotives, (viii) fireless locomotives, (ix) accumulator cars, complete, (x) trolley cars, (xi) conduit cars, as well as the average number of cars required for lines of various characters. E. H. C.-H.

1009. *Electrical Equipment of the South-Eastern and Chatham Railway Company's Locomotive Sheds.* (Electrician, 46. pp. 305–309, Dec. 21, 1900.)—An account is given of the power station erected by the Company at Slade's Green. The article contains some particulars of two electric cranes used in the sheds, which are operated from a cage at the one side below the beam. W. H. S.

1010. *Electric Power and Lighting in a Smelting Works.* **L. Gohs.** (Elektrotechn. Zeitschr. 21. pp. 1038–1046, Dec. 13, 1900.)—A detailed and illustrated account is given of a 1000-kw. installation in South Russia. The system is direct current at 2×125 volts, and extensive use is made of motors. W. H. E.

1011. *Series Alternating Current Arc Lamps.* **H. W. Hillman.** (West. Electn. 27. pp. 130–132, 1900. Paper read before the Ohio Electric Light Association at Toledo, Aug. 16, 1900.)—Further details of work carried out on this system. [See Abstract No. 735 (1901).]

1012. *Vienna Tramways.* (Zeitschr. Elektrotechn., Wien, 19. pp. 35–36, Jan. 20, 1901.)—The conditions of the concession by the Austrian Government of the right to convert the Vienna tramways to an electrical system are here given, in so far as these conditions refer to the construction of the line, or to matters of engineering detail.

TELEGRAPHY AND TELEPHONY.

1013. *Type-Printing Telegraphy.* **W. B. Vansize.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 1–23, Jan., 1901.)—The writer describes the apparatus designed by D. Murray for automatic type-printing telegraphy. At the transmitter a special alphabet is employed which is perforated on the transmitter-tape by a keyboard perforator having a separate movable lever for each character. Each character occupies the same linear space on the tape, 0·5 inch, and consists of five subdivisions or elements, either perforations or blanks. There is consequently no need for the use of differential feed mechanism to provide for letters of varying length. The keyboard carries ten punches, one punching magnet, and one spacing magnet, controlling a motor-driven escapement. At the receiving station there is an electro-magnetic perforating device which reproduces the transmitting tape spaces and perforations. This tape next passes through an automatic type-writing machine consisting of five longitudinally reciprocating bars, the ends of which engage with five holes in a plate. The tape moves along between the perforated plate and the bars, step by step, one character at a time. When there is coincidence between the bars, the perforations of the tape, and the holes in the plate, contact is made as in the ordinary Wheatstone automatic machine, and by means of a set of notched strips laid across the bars at right angles and a cam-driven electro-motor, the keys of the type-writing machine are depressed, or those of any type-setting or linotype machine can be actuated. The paper includes an account of the mechanism and electrical connections, and also of the method employed for maintaining unison. The best speed attained over 1,050 miles (land lines) was 77 words per minute, counting five letters to a word, assuming a word-space equal to one letter. R. A.

1014. *Sine-wave Transmitter for Cables.* **A. C. Crehore** and **G. O. Squier.** (Elect. World and Engineer, 36. pp. 481–482, Sept. 29, 1900; also Electrician, 45. p. 744, Sept. 7, 1900. Abstract of a paper read before the International Electrical Congress at Paris, Aug. 23, 1900.)—The apparatus was described in Abstract No. 1969 (1900). A trial was made from London to Aberdeen. With the ordinary Wheatstone transmitter the limit of speed on that circuit was 107 words per minute; with the sine-wave transmitter this was increased to 195 words per minute. This increase of speed is partly due to the use of higher voltage. Such high voltages cannot be employed with square-topped sending, owing to sparking at the contacts; but with the sine-wave transmitter the currents are interrupted only at zero instants whatever the e.m.f. Also, sine-wave impulses travel at greater effective velocity through the cable than square-topped impulses of equal frequency. The authors claim that on long cables the speed of signalling can be doubled by sine-wave transmitters. R. A.

1015. *Spark-telegraphy.* **A. Slaby.** (Elektrotechn. Zeitschr. 22. pp. 38–42, Jan. 10, 1901. Report read before the Allgemeine Elektricitäts-Gesellschaft, Dec. 22, 1900; also Electrician, 46. p. 475, Jan. 18, 1901.)—In the case of the earth-wire as used in wireless telegraphy, there is a potential node at the

earthed end, and a potential loop at the free end; hence the theoretical length of the resonant wave is four times the length of the air-wire. The practice has been to lead the insulated air-wire to one terminal of the coherer, the other terminal of the coherer being put to earth. The comparatively large capacity of the coherer, however, makes its air-wire terminal a potential node, so that the arrangement responds to some secondary wave. Slaby therefore connects the air-wire directly to earth. To the air-wire he also connects a second wire equal to it, having itself a free end. This second wire may be stretched out in a horizontal direction, or it may be wound on a bobbin. At its free end there is produced a potential loop similar to that at the free end of the air-wire. The practical details have been worked out by Arco, but the description of them is very incomplete. It is claimed that both syntony and selection can be attained by adjustment of the capacity and induction.

R. A.

1016. *Depth of Penetration of Hertzian Waves into the Earth in Wireless Telegraphy.* **E. Lagrange.** (Comptes Rendus, 132. pp. 203–204, Jan. 28, 1901.)—The author describes experiments in which he found that a receiver buried to a depth of 30 cm. is not acted on by waves emitted by a transmitter in its vicinity.

J. E. M.

1017. *Syntonic Wireless Telegraphy.* **R. Blochmann.** (Elektrotechn. Zeitschr. 22. pp. 80–82, Jan. 24, 1901. Report read before the 8th Jahresversammlung des Verbandes Deutscher Elektrotechniker in Kiel, June 19, 1900.) —The author gives a brief history of wireless telegraphy, and then states a theory which he has evolved from consideration of the supposed action of the potential of the vertical wire on the equipotential surfaces due to atmospheric electricity.

J. E.-M.

1018. *Schäfer's "Anti-coherers."* **E. Marx.** (Phys. Zeitschr. 2. pp. 249–253, Jan. 26, 1901.)—These appliances take the place of coherers. They consist of fine linear flaws in a deposit of silver upon glass, and they are made by lightly drawing a fine line with a diamond. Under the impact of electric waves the resistance of the flaw (about 40 ohms for 30 mm.) is increased about threefold, and promptly falls to its original value when the waves cease. The action is so distinct that signals can be received on the open sea at 95 km. distance, which is beyond the range of the coherer. Righi had used slits for the production of sparks by resonance and Neugeschwender for increasing the resistance of the slit upon the impact of electric waves in cases where there is a film of moisture bridging the gap. But in this case the slit is ragged, and there are conducting metallic bridges across the gap and loose particles of silver which fly to and fro when the p.d. across the gap is 3 volts or more: and the presence of moisture is prevented by careful drying of the air in the tube. The current passed is about 30 milliamperes when there are no electric waves. The original value of the resistance is so rapidly restored that signals can be heard in a telephone with extreme sharpness, and with a pair of telephones two persons can listen to independent simultaneous signals of different rhythm, from different inductors. The puppet-dance of particles of silver across the gap causes a sound in the telephone, at about 3 volts p.d., and is visible under a microscope. With a dry gap, breathed upon, electrolysis produces particles of silver which oscillate in the same way; and when the film of moisture disappears, these particles continue to dance and make noise in the telephone. When electric waves impinge on the "anti-coherer," the metallic

bridges disappear, temporarily; this accounts for the temporary increase in resistance; but the bridges may not be restored in identical places. At the same time the pitch of the sound heard in the telephone temporarily alters. The appliance may be strengthened and rendered more durable by coating with a solution of collodium in ether. On drying this seems to form cavities in which the loose silver can move; for if shellac in alcohol be used instead, and heated, the whole becomes hide-bound and acts no longer. On exhausting repeatedly under an air-pump the collodion cavities seem to be expanded, and the sensitiveness is increased, up to a limit beyond which the expansion begins to become too great for the number of silver particles present. Silver, somewhat spongy and blue, works best; gold and platinum do not work; with bismuth it is difficult to make a satisfactory slit. The action of the apparatus does not depend upon the length of the slit: and the same results can be obtained by making *one* connecting bridge, say $\frac{1}{10}$ mm. wide, in an indefinitely wide gap, and coating with collodion. The contrivance works much more steadily and less capriciously than the ordinary coherer. A. D.

1019. *Telegraphone Practice.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 129–130, 1900.)—The introduction of a polarising cell into the circuit of the recording magnet of the telegraphone considerably increases the sharpness and clearness with which the sound is rendered. This observation is explained by the author as follows: The preliminary magnetisation probably never exceeds 12,000 units, and after the wire leaves the neighbourhood of the electromagnet its magnetic intensity probably falls to about 8,000 units. When the wire is used for recording, its remanent magnetism will then induce pretty high magnetisations in the core of the recording electromagnet, with a maximum of some 8,000 units. Now this value, when looked up on the curve of magnetisation, is seen to correspond to a low permeability, where comparatively large variations of the magneto-motive force only produce small variations of the magnetic flux, and therefore, also small amplitudes of the magnetic waves to be impressed upon the wire. But for loud records it is important that the variations of the magneto-motive force should take place on a steep portion of the magnetisation curve. That condition is fulfilled by introducing a cell in the circuit which shall just compensate the magnetism induced by the wire in the core of the electromagnet. In Poulsen's case the e.m.f. required is only 1 volt. E. E. F.

REFERENCES.

1020. *Cabic Speeds.* **F. Breisig.** (Elektrotechn. Zeitschr. 21. pp. 1046–1050, 1900. Communicated by the Kaiserl. Telegraphen-Versuchsamt.)—The author investigates the limits of speed in working through submarine cables, in extension of the method used by W. A. Price (Electrical Review, vol. 41. p. 190, 1897), with special reference to the effect produced on the speed by the condensers and other apparatus at the sending and receiving stations. R. A.

1021. *Telephonic Trasmission.* **W. A. Price.** (Elect. Rev. 48. pp. 9–10, Jan. 4, and 92–95, Jan. 18, 1901.)—A paper occupied with the problem of the possible improvement of the London to Birmingham underground telephone lines by inserting inductive coils or leaks at each of the twenty-two testing-posts which occur at distances of five miles along the line. The theories of O. Heaviside and the work of M. I. Pupin [Abstract No. 2122 (1900)] are applied to the case, and numerical results obtained and discussed. E. H. B.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1901.

GENERAL PHYSICS.

1022. *Mechanical Properties of Caoutchouc.* **M. Cantone** and **G. Contino.** (N. Cimento, 12. pp. 242–257, 1900. Rend. R. Istit. Lombardo di sc. e lett. 31. p. 1521, 1898.)—The authors study the influence of traction and torsion on caoutchouc, and add some notes on its thermal expansion. The samples were of the red variety prepared by Pirelli & Co. It appears that as the load increases there is an increase in the modulus, and not a diminution as postulated by Villari and Röntgen. This is opposed to the behaviour of the metals. As regards torsion, the material behaves in essentially the same manner as do the hard metals. E. E. F.

1023. *Compressed-Air Manometer.* **S. Lussana.** (N. Cimento, 12. pp. 237–241, 1900.)—The manometer consists of an iron tube with air-tight caps, along the axis of which a platinum wire is stretched. The pressure to be measured forces mercury into the tube, and this compresses the air contained in the tube. The extent to which the mercury rises in the tube is measured by the length of the platinum wire submerged, and this again is measured by determining the resistance of the unsubmerged wire. The manometer may be used for pressures varying from 1 to 600 atmospheres. E. E. F.

1024. *Centrifugal Laboratory-Pump.* **E. Jordis.** (Zeitschr. Elektrochem. 7. pp. 464–466, Feb. 14, 1901.)—Specially designed for the determination of potential differences in electrolytes circulating at a constant speed. It is a centrifugal pump, consisting of a suction and a compression chamber, built up entirely of glass and rubber without any valves ; the steel shaft is protected by a glass tube. The pump is made by Bender and Hobein, of Munich, and resembles the electrolyser of Wehrlin. When the supply and return pipes are coiled, the pump may be used as a thermostat, as it easily maintains a constant temperature.

Experiments show that the influence of the rate of circulation of an electrolyte ceases when a certain speed is exceeded. H. B.

1025. *Electrical Absorption Dynamometer.* **E. H. Rieter.** (Elektrotechn. Zeitschr. 22. pp. 194–196, Feb. 28, 1901.)—An illustrated description of an

electrical absorption dynamometer consisting of an electromagnet provided with a single exciting coil and pole-pieces of alternate polarity curving back over the coil. The electromagnet is movable through a limited range about its axis. Surrounding the two crowns of pole-pieces is an iron or steel ring furnished with numerous thin ridges for carrying off the heat. The ring is coupled to the motor under test. The electromagnet carries two levers, one of which is graduated and fitted with a sliding weight, while the other is arranged to take heavier weights occupying one fixed position, exact balance being obtained by means of the sliding weight. A. H.

1026. *Viscosity of Solids.* **R. Reiger.** (Phys. Zeitschr. 2. pp. 213–217, Jan. 5, 1901.)—The author studies the "time of relaxation" in colophonium, gelatine, and chilled glass. He finds that in their plastic state these substances show a relaxation in accordance with Maxwell's theory, whereas in the hard state the viscosity rises first to a maximum before relaxation sets in. With falling temperatures the time of relaxation and the viscosity increase rapidly. A regular relaxation is only found within the range of validity of Hooke's law. After the maximum tension is attained in dried gelatine the relaxation sets in rapidly at first, and then very much more slowly. E. E. F.

1027. *Passage of Gases through Capillary Tubes.* **A. Job.** (Soc. Franç. Phys., Bull. 157. p. 2, 1901.)—The author describes a method of measuring the resistance offered by capillary tubes to the flow of gases; a voltameter is provided with a capillary tube outlet. The pressure produced in the voltameter, for a given current, measures the resistance of the capillary tube. The author suggests the application of this method to various experiments connected with the flow of gases. G. H. B.

1028. *Deformation of Solids.* **A. Mesnager.** (International Physical Congress at Paris, Report, 1. pp. 348–362, 1900.)—An isotropic solid subjected to force is elastically deformed according to the laws of the theory of elasticity if the principal forces at every point are such that—

$$\gamma > \frac{\nu_3}{1-\eta} - (\nu_1+\nu_2+\nu_3)\frac{\eta}{1+\eta}, \quad \ldots\ldots\ldots\ldots (1)$$

and—

$$\delta > \frac{\nu_3+\nu_1}{2}\frac{1-2\eta}{1-\eta}\tan\psi + \frac{\nu_3-\nu_1}{2(1-\eta)}\frac{1}{\cos\psi}, \quad \ldots\ldots (2)$$

where γ is the cohesion (measured by breaking strains); $\nu_3 > \nu_2 > \nu_1$, the principal tensions; η the ratio of elongation to lateral contraction in simple traction; δ the hardness; $\tan\psi$ the coefficient of internal friction, which appears to be constant; $\psi = 2\alpha - \frac{\pi}{4}$, α being the angle between Hartmann's lines and the direction of simple traction. If condition (2) be satisfied, but not (1), the body breaks without preliminary permanent deformation, like glass for example; if the converse hold good, there is a permanent deformation; δ increases in general with the deformation, and consequently the deformation is limited and uniform. If δ decreases, there may be rupture by sliding. In order to predict the slow deformations of an isotropic solid at a given temperature, it is necessary to know γ, α, and δ. Experimental methods are described for tracing the distribution of the resultant forces in glass and the variations of thickness, by means of double refraction; and examples are worked out. In permanent deformations the volume remains the same. In

deformation beyond the limit of elasticity, if the stress be somewhat relieved the strain is relieved in an elastic manner, the coefficient of elasticity being in this case the same as that below the limit of elasticity; on the stress being restored the strain is also restored; and on the strain being further increased the stress goes on to a maximum. Beyond this maximum, in the case of traction, striction begins and goes on until rupture takes place. The resistance per unit of area increases constantly during the traction, even during the period of striction. Permanent deformation is due to sliding movement along planes at a fixed angle to the direction of traction. A. D.

1029. *Energy Accelerations.* **G. H. Bryan.** (Archives Néerlandaises, 5. pp. 279–294, 1900.)—The author defines as *energy accelerations* the second differential coefficients with respect to time of the squares and products of the velocities which enter into the expression for the kinetic energy of a system. He suggests a method of determining the distribution of velocities needed for the state of a system to be stationary when the probability that its co-ordinates lie between assigned limits is given. This consists in equating to zero the mean values of the energy accelerations and investigating the resulting conditions, which are called the *equations of energy equilibrium.* The conditions of stability are obtained by assuming that the mean values of the energy accelerations differ from their equilibrium values by harmonic functions of the time of period $2\pi/p$, forming therefrom the equation for determining p^2, and finding the conditions that this equation has real roots. The mean values are found on the assumption that the proper measure of the probable distribution of the co-ordinates of a system does not depend on the motions of the molecules and remains independent of the time so long as the energy and controllable co-ordinates of the system are constant. The investigation is complicated except in the simplest cases, as for n molecules, each with 3 degrees of freedom, there are $3n(3n+1)/2$ energy accelerations to consider. The author discusses three cases:—(1) When a single particle moves rectilinearly in a field of force; (2) when two attracting or repelling particles move in a straight line in a field of force; (3) when a single particle moves in any field of force in a plane. He finds that Maxwell's law of the partition of energy holds good in case (1), and in case (2) if the field of force vanishes; but not generally otherwise.

The advantage of this method is that it enables us to account for irreversible phenomena in a system the elements of which satisfy the equations of reversible dynamics; for the direction of transference of energy between two systems will depend on the sign of an inequality which involves only squares and products of velocities, so that the sign is unchanged by the reversal of all the velocities of the systems.

The liquefaction of a gas or the solidification of a liquid, by the passage of energy in the form of latent heat from the portion of the substance in the lower state to that in the higher, may be explained from the general properties of unstable equilibrium; and as instability may also lead to an increase in the mean kinetic energy of a system at the expense of its potential energy, or *vice versâ*, certain chemical phenomena may find a kinetic interpretation.

R. E. B.

1030. *Units.* **C. E. Guillaume.** (International Physical Congress at Paris, Report, 1. pp. 78–100, 1900.)—In the first part of the paper the author gives a *résumé* of the work done by the Commissions of 1872 and 1887 in establishing standards and definitions of the metre, the kilogramme, the litre,

the international ohm, and the ampere and volt, and deals briefly with the photometric standards adopted in 1884 and 1896. In the second part the author discusses the various quantities, the units of which have not yet been standardised. As regards the unit of pressure, the Commission delegated by the Société de Physique has recommended the pressure of a column of mercury 75 cm. long, at 0° and at sea-level at latitude 45° ; this pressure is equal to one megadyne per square cm. within 1 part in 15,000, and the proposed name is a "*barye*." Since Stefan's law has been experimentally confirmed for a black body, the author proposes as a measure of emissive power, the coefficient, which, multiplied by the surface of the radiating body in square cms. and by the fourth power of the absolute temperature, expressed in thousands of degrees Centigrade, gives in watts the value of the power radiated. The author discusses the possibility of determining a photometric standard in terms of the light emitted by a black body at a certain temperature, and criticises the proposed division of the spectrum into octaves, or regions comprised between two wave-lengths, one double the other. The paper concludes with a note on the latest determinations of the densities of water and of mercury. For the former, at 4° C., the author considers the figure 0·999955 correct to within two units in the fifth place, and for the latter, the figure 13·5950 correct to within three or four units in the fourth decimal place.

G. H. B.

1031. *Motion of an Ether assumed to be Fluid.* **G. Mie.** (Phys. Zeitschr. 2. pp. 319–325, Feb. 23, 1901. Paper read before the Naturforscherversammlung zu Aachen.)—If ether be a fluid it must be set in motion by such processes as the discharge of condensers, &c., and there must then be loss of energy. The object of the writer is to consider, using Helmholtz's method, the existence or non-existence of such motions of ether. After referring to his controversy with Wien [see Abstracts Nos. 484 and 485 (1901)] he lays down three assumptions, following Helmholtz :—(1) The forces acting on ether are conservative forces, *i.e.*, have a single valued potential. (2) The ether in its motion presents the properties of a frictionless incompressible fluid. (3) The energy of a particle of ether is the sum of three parts—electric, magnetic, and stream energy.

Of these assumptions (2) and (3) are not fulfilled by Kelvin's rotational ether or Sommerfeld's ether.

Let μ denote the mass per unit volume ; α, β, γ, the component velocities of the fluid ; and let

$$\frac{d\gamma}{dy}-\frac{d\beta}{dz}=x', \quad \frac{d\alpha}{dz}-\frac{d\gamma}{dx}=y', \quad \frac{d\beta}{dx}-\frac{d\alpha}{dy}=z' :$$

also let u, v, w, be the components of Poynting's vector, and $\xi=\frac{dw}{dy}-\frac{dv}{dz}$, &c.

Then the author obtains by Helmholtz's method three equations :—

$$\mu x' = A^2\xi + a$$
$$\mu y' = A^2\eta + b$$
$$\mu z' = A^2\zeta + c$$

Here a, b, c are the components of a vortex, the lines of which form a vortex tube according to Helmholtz's well-known theorem. For this vortex only two assumptions are possible. Either (1) these vortices fill the ether in regular order, as discussed by Kelvin in Phil. Mag. 1887, in which case the ether must have properties differing from those of ordinary fluids ; or (2) $a=b=c=0$.

In order to agree with assumption (2) the author chooses the second alternative. Hence it follows that the vortex lines in the motion of pure ether coincide with the vortex lines of Poynting's vector.

The author then makes two further assumptions :—(3) Ether is not only incompressible, but also of unlimited cohesion. (4) Molecules of bodies are completely penetrable by ether.

Following on this assumption, atoms are singular points, *i.e.*, origins of electric stress, in ether, and ether freely passes through them without carrying them with it in its own motion. If at first sight this presents a difficulty it is sufficient to suppose, he says, that the singular point which is the nucleus of the atom, is infinitely small compared with the distance between two centres.

The author applies his theory to several cases on the assumption that the variation of the field in the immediate neighbourhood of an atom due to the ether motion is to be neglected. If, however, we consider spaces of smaller than molecular dimensions this can no longer be done. It appears, he says, that in that case the presence of the atom, even though it be freely penetrable by ether, has an effect on the ether current; and he proposes to consider in a future paper the modification which will on this account be necessary in his equations. S. H. B.

1032. *Vortex-Rings.* **R. W. Wood.** (Nature, 63. pp. 418–420, Feb. 28, 1901.)—Experimental apparatus described, for producing and photographing vortex-rings, wholly or only partially charged with smoke. Vortex-rings can be produced by driving the smoke through a cullendar or through stretched linen cloth. Two rings side by side, if rotating rapidly, will bounce apart; but if they are sluggish they will coalesce first into an oscillating dumb-bell and ultimately into a circular form. A. D.

1033. *Constant of Gravitation.* **C. V. Boys.** (International Physical Congress at Paris, Report, 3. pp. 306–349, 1900.)—In this Report the author gives a historical sketch of the different investigations made up to the present time to find the value of the mean density of the earth and the gravitational constant. The various laboratory methods that have been adopted are described, and their difficulties discussed from the point of view of the practical experimenter. The following are the values found for Δ, the mean density of the earth, by the author and other recent experimenters :—

	Δ
Boys	5·527
Braun	$\begin{cases} 5{\cdot}52700 \pm 0{\cdot}0014 \\ 5{\cdot}52725 \pm 0{\cdot}0012 \end{cases}$
Eötvös	$5{\cdot}55 \pm 0{\cdot}01$
König, Richarz, and Krigar-Menzel	5·505.

W. C. H.

1034. *Variation of Gravity over the Surface of the Earth.* **R. Bourgeois.** (International Physical Congress at Paris, Report, 3. pp. 350–370, 1900.)—In the first part of this Report, the author gives a short sketch of the various pendulum experiments from the time of Galileo up to the present time, tracing the gradual elimination of imperfections in the apparatus. In the second part the results of these experiments, giving values of g at different places on the earth's surface, are discussed. From all these results we ought to be able

to calculate the variation of weight from the equator to the pole and so deduce the eccentricity of the earth by the formulæ of Clairaut and Laplace :—

$$\frac{g_p - g_{eq}}{g_{eq}} = \frac{5}{2}m - e = \frac{l_p - l_{eq}}{l_{eq}},$$

$$l\phi = l_{eq} + (l_p - l_{eq})\sin^2\phi,$$

where e is the eccentricity, ϕ the latitude, and m the ratio of equatorial centrifugal force to equatorial weight ($= \frac{1}{289}$). The author shows, however, that we have not yet sufficient results, and that those we have present too many anomalies and difficulties of various kinds to allow of comparison with one another. W. C. H.

1035. *Rotation of a Body partly Solid and partly Fluid.* **G. de Prato.** (N. Cimento, 5. pp. 41–50, Jan., 1901.)—A study of the equations of motion of a system of points, of material partly solid and partly fluid, in which the motions are such as to leave the distribution of matter unchanged, this result being due to the mutual action of the various points, under a gravitation law, with special reference to the earth considered as such a system. A. D.

1036. *Anomalous Dispersion and Spectrum of Chromosphere.* **R. W. Wood.** (Astrophys. Journ. 13. pp. 63–67, Jan., 1900.)—Acting on a suggestion put forward by W. H. Julius [see Abstract No. 33 (1901)] that the "flash" spectrum seen immediately at totality may be due to photospheric light abnormally refracted, the author has been successful in devising an experiment whereby such a line spectrum may be produced in the laboratory, *i.e.*, he has been able to see a spectrum of bright lines with light from a source showing a continuous spectrum, by means of causing it to suffer anomalous dispersion in an incandescent metallic vapour. The theory of Julius assumes the sun surrounded by an atmosphere of metallic vapours, whose density and refractive index decrease with increasing distance from the surface. The refractive index for any ray will be small except for wave-lengths near those which are absorbed by the vapour, so that the light most strongly refracted will be that closely resembling the rays emitted by the metallic vapours. The graduated layers of vapour were obtained by allowing the flame of a Bunsen burner fed with metallic sodium to play on the under surface of a white plaster plate. A narrow dark space is seen to exist between the flame and plate. The edge of the flame was then illuminated by sunlight from a large mirror, the white light thus emitted corresponding to the photospheric radiation. This was examined by a telescope with a direct vision objective prism, adjusted until the Fraunhofer lines were visible. On placing fresh sodium in the Bunsen flame the solar spectrum vanished, and was replaced by two bright lines in the place of the previous dark sodium lines. These at once disappeared if the sunlight was cut off. Repetition of the experiment showed that the places of the flash bright lines were slightly more refrangible than the original dark ones.

Further experiments showed that abnormally dispersed light was also to be detected on the red side of the normal lines. Good results have been obtained with potassium and thallium, and it is hoped to obtain similar spectra with light sources of more complicated constitution, and more precise determinations of the refractivity of metallic vapours are being obtained by the use of a hollow metal prism with mica windows. C. P. B.

1037. *Nature of Solar Corona.* **R. W. Wood.** (Astrophys. Journ. 13. pp. 68–79, Jan., 1901.)—This paper consists of a suggestive discussion of the facts brought forward by the work done at the last few eclipses, and indicates the lines along which future research might profitably extend. The presence of polarised light in the spectrum must be taken as a positive proof of the existence of minute solid particles, as under no conditions known to the author has an electrically excited gas been found to emit polarised light. As to the absence of the Fraunhofer lines making it doubtful if the light is reflected sunlight, it may be that the oblique prism faces are such as to stop the polarised light. A method suggested for eliminating this is to use a Nicol before the slit, which is set tangential to the solar image, in which case the polarised rays will be transmitted by the prism and the dark lines might thus be rendered visible.

Experiments are then described illustrating the reflection of light by flames, illustrated by several photographs. A case apparently closely resembling the conditions of the corona was obtained where the use of the Nicol did bring out the dark lines which were otherwise invisible. It also indicated that the flame reflects comparatively little of the red or orange rays, so that success would be most probable by examining the actinic part of the spectrum. This fact may account for the absence of heat radiations from the coronal spectrum, as determined during the last eclipses.

Some interesting experiments are also described bearing on the temperature to which the particles of the corona will be subjected from the direct photospheric radiations. Using a concave speculum of variable area, a temperature of 1,100° C. was obtained, copper being melted with ease. The remainder of the paper is occupied with a long and useful discussion of the bearing of these experiments on the nature of the corona. C. P. B.

1038. *Motion of the Solar System.* **W. W. Campbell.** (Astrophys. Journ. 13. pp. 80–89, Jan., 1901.)—Since the satisfactory adjustment of the Mills spectrograph at the Lick Observatory in 1896, Campbell has obtained some 2,000 spectrograms, 1,500 of which show satisfactory spectra of about 325 stars. It is not yet possible to give the detailed reductions for each star, but from 280 of them a determination of the motion of the solar system has been deduced. The observations were divided into groups, and the equations of condition and reduction are given. The elements of the solar motion thus determined are—

$$V = -19{\cdot}89 \text{ km.} \pm 1{\cdot}52 \text{ km.}$$
$$\text{R.A. of apex} = 277^\circ\ 30' \pm 4^\circ{\cdot}8$$
$$\text{Decl.} \quad ,, \quad = +19^\circ\ 58' \pm 5^\circ{\cdot}9$$

Comparisons with the determinations of other observers, and the questions of spectroscopic binaries and relative motions of faint and bright stars occupy the remainder of the paper. C. P. B.

1039. *Formation of Hailstones.* **L. Bombicci.** (Elettricità, Milan, 20. pp. 34–37, Jan. 19, 1901.)—This paper is a discussion, with some criticisms of Artom's theory of the formation of hailstones [Abstract No. 345 (1901)]. The author does not think that hailstones can be formed by the rotation of frozen particles of water, on the point of crystallisation, but compares them with the spheroidal crystals of various minerals, which are formed in more or less solid media, where any rotatory motion would be impossible. He believes their formation to take place in a cold atmospheric region, saturated with

minute water crystals (generally electrified by friction with the air), when these come into contact with swarms of frozen amorphous granules; such swarms are formed in higher and colder layers by the rapid freezing of water-vapour contained in ascending columns of warm and damp air. The author also criticises Artom's theory of the action of hail-preventing cannons. G. H. B.

REFERENCES.

1040. *Oscillations of Lakes.* **F. A. Forel** and **É. Sarasin.** (International Physical Congress at Paris, Report, 3. pp. 394–408, 1900.)

1041. *Ice and Glaciers.* **E. Hagenbach.** (International Physical Congress at Paris, Report, 3. pp. 409–414, 1900.)

1042. *Kinetic Theory of Planetary Atmospheres.* **G. H. Bryan.** (Roy. Soc., Phil. Trans. 196. pp. 1–24, Feb. 18, 1901.)—This paper was referred to in Abstract No. 37 (1901), but is here given in its complete form.

1043. *Atmospheres of the Earth and Planets.* **M. v. Smoluchowski.** (Phys. Zeitschr. 2. pp. 307–313, Feb. 16, 1901. Extract from a paper in a Jubilee Publication of the Lemberg University.)—This paper contains a very general discussion of the views which have been entertained regarding the diminution of temperature and density upwards in the atmosphere, and the existence of a limit to its extent. In the concluding portion the author expresses his disagreement with the views put forward by Johnstone Stoney. A. E.

1044. *Mounting for Tube Containing Liquefied CO_2.* **E. H. Hall.** (Phys. Rev. 12. pp. 125–126, Feb., 1901.)—An arrangement is described for making the meniscus vanish and reappear by means of water at, say, 27° C. A. D.

LIGHT.

1045. *Radiation of a Black Body.* **O. Lummer.** (International Physical Congress at Paris, Report, 2. pp. 41–99, 1900.)—This report contains a synopsis of most of the experimental work which has been done on the radiation of a black body, together with a critical review and comparison of the results of theory and experiment. The most important researches are those of Lummer and Pringsheim, Lummer and Kurlbaum, Rubens, Beckmann, Paschen, and Wanner. The law of Stefan,

$$S = \int_0^\infty E d\lambda = \sigma\theta^4,$$

and the displacement law of Wien,

$$\lambda_m\theta = \text{const.} = A,$$

have been proved both experimentally and theoretically. The third equation,

$$E_m\theta^{-5} = \text{const.} = B,$$

follows immediately from these two.

The various formulæ which have been deduced to express the partition of energy in the spectrum of a black body are all discussed, and the conclusion is come to that more experimental knowledge is required before any decision can be come to as to which of the formulæ actually represents the facts. These formulæ are given by the general formulæ of Lummer and Jahnke—

$$E = C\theta^{5-\mu}\lambda^{-\mu}e^{-\frac{c}{(\lambda\theta)^\nu}},$$

in which, if $\nu = 1$ and $\mu = 5$, we have Wien's formula; if $\nu = 1$ and $\mu = 4{\cdot}5$, we have that of Thiesen; and if $\nu = 1$ and $\mu = 4$, the formula is that of Rayleigh.

J. B. H.

1046. *Radiation and Draper's Law.* **O. Lummer.** (Archiv. Math. Phys. 1. pp. 77–90, 1901.)—This is the first of two papers in which the author is going to treat in a somewhat fuller manner the radiation problems which he dealt with in his address to the Paris Congress. The present paper deals with the supposed law, first propounded by Draper, that all bodies begin to emit light at the same temperature. After adversely criticising Draper's and Kirchhoff's conclusions drawn from their experiments on this point, the author gives a *résumé* of the more recent researches on the subject. The first sensation of light as the temperature of a body is gradually raised in a dark room is the "grey-glow," now known to be due to the rods in the retina, but this can scarcely be called emission of light, since the human eye cannot then bring the body to a focus, the attempt only serving to make the body invisible again. This is due to the distribution of the rods and cones in the human retina. The first real sensation of light takes place at a much higher temperature, which varies with the body emitting it, so that here Draper's law does not apply. Whether it applies to the "grey-glow" is very doubtful. The author has observed the grey-glow as low as 360° C.

J. B. H.

1047. *Radiation of a Black Body.* **C. E. Mendenhall** and **F. A. Saunders.** (Astrophys. Journ. 13. pp. 25–47, Jan., 1901.)—This paper starts with a short *résumé* in tabular form of the various so-called "laws" which have been obtained (for the most part theoretically) for the radiation of a black body, and which have lately been put to test by experiment. Some experiments which the authors have carried out with the same object are then described. These experiments have led to rather inconclusive results owing to the great experimental difficulties, and the authors conclude that no results of sufficient accuracy can be obtained without taking excessive precautions in regard to the "blackness" of both radiator and bolometer strips, and in excluding from the air about the apparatus all traces of carbon dioxide and water vapour. The experimental difficulties are fully dealt with. J. B. H.

1048. *Radiation of Black Bodies.* **C. E. Guillaume.** (Ind. Élect. 10. pp. 101–103, March 10, 1901.)—The radiation of a black (hollow) body is compared with that of platinum by means of Lummer and Kurlbaum's method. The author gives the following results, showing the relation between the absolute temperature θ, the brightness E of the black body, and the luminous output R—

θ	E	R
900	0·069	1·10
1,000	1·000	1·00
1,100	7·729	5·28
1,200	40·89	19·72
1,300	167·4	56·61
1,400	569·3	148·2
1,500	1,682	332·2
1,600	4,445	678·2
1,700	10,740	1,286
1,800	24,110	2,297
1,900	50,830	3,900
2,000	101,600	6,350

The efficiency is calculated on the basis of Stefan's law, according to which the total energy dissipated is proportional to the fourth power of the absolute temperature. E. E. F.

1049. *Radiation of a Black Body.* **F. Paschen.** (Ann. d. Physik, 4. 2. pp. 277–298, Feb., 1901.)—The investigations made by the author himself and Wanner showed the validity of Wien's law for a large range of comparatively small values of λT [see Abstract No. 1348 (1899)]. That law is expressed by—

$$J = c_1 \lambda^{-5} \varepsilon^{-\frac{c_2}{\lambda T}},$$

where J is the energy of the radiation of wave-length λ and T is the absolute temperature. Further experiments have proved, however, that though Wien's law holds good for small values of λT, Thiessen's formula—

$$JT^{-5} = f(\lambda T)$$

agrees more closely with the experiments of Lummer-Pringsheim and Beckmann-Rubens. And at large values of λT Rayleigh's formula corresponds more closely with the values found by Rubens and Kurlbaum.

But the whole set of measurements available are really covered by Planck's new formula—

$$J = c_1\lambda^{-5}\frac{1}{e^{\frac{c_2}{\lambda T}}-1}$$

and whereas c_2 is $5\lambda_m T$ in Wien's formula, it is $4{\cdot}9651\ \lambda_m T$ in Planck's. The latter is completely verified over a range of $1/\lambda T$ extending from 0·002 to 0·00001. E. E. F.

1050. *Selective Reflection.* **F. Paschen.** (Ann. d. Physik, 4. 2. pp. 304–306, Feb., 1901.)—The tests of reflective power for various wave-lengths were carried out on one silver mirror freshly prepared and polished, one newly silvered glass plate, one old silvered glass plate, and a German-silver mirror. For a wave-length of 0·7786 μ the solid silver mirror showed a reflective power of 94·24 per cent., the two silver-on-glass mirrors 91.96 and 85·15 per cent. respectively, and the German-silver mirror 70·89 per cent. For a wave-length of 7·737 μ the corresponding figures were 98·69, 98·46, 96·17, and 94·03. E. E. F.

1051. *Refractivities of the Inactive Gases.* **W. Ramsay.** (Archives Néerlandaises, 5. pp. 356–359, 1900.)—Using the apparatus devised by Rayleigh for the refractivity of argon, the following values were found for the refractivities of this and the other inactive gases of the atmosphere—

Helium.	Neon.	Argon.	Krypton.	Xenon.
0·1238	0·2345	0·968	1·449	2·364

These numbers express the refractivities compared with air, and are proportional to $(\mu - 1)$. On division of these numbers by the densities of the gases, or by their atomic weights, a series of figures is obtained which expresses the retardation of light by equal quantities of matter. These quotients are respectively 0·0309, 0·0172, 0·0242, 0·0177, and 0·0184. Thus the quotients for helium and argon are high, while neon, krypton, and xenon yield almost the same numbers as each other. E. H. B.

1052. *Photographic Action of Dark Light.* **W. J. Russell.** (Roy. Inst., Proc. 16. pp. 140–146, 1900.)—This paper is a popular description of the action produced on photographic plates by various metals and organic substances, notably the turpenes and oils, and of the transparency of different substances to this radiation. G. H. B.

1053. *Preservation of Photographic Plates.* **C. Jones.** (Nature, 63. pp. 373–374, Feb. 14, 1901.)—The paper refers to Lockyer's article [Abstract No. 783 (1901)] in which gold toning is recommended as a means of preserving negatives of star photographs and other subjects, where it is of the utmost importance that the image should be absolutely permanent. The author deprecates the use of gold toning on the ground that the resulting deposit is of a complex character, and may be subject to changes which cannot be foreseen, and also because toning is an incomplete operation and does not produce a proportional change throughout the image, with the result that measurements of the effect of light are rendered of doubtful value. He proposes instead a more careful treatment of the silver image. Ammonia, potassium, cyanide, sodium thiosulphate, and ferric oxalate

dissolve metallic silver in the presence of air; these should therefore be avoided as far as possible in the processes of development and fixing. Alkaline developers can replace ferrous oxalate, the ammonia can be replaced by sodium carbonate, and the thiosulphate should be removed by a prolonged washing. The author recommends a plentiful use of sodium sulphite in the developer to prevent the deposition of staining matter; acid clearing baths are injurious, they only lighten the colour of the stain and render it insoluble; alkaline baths have the opposite effect, and a little carbonate of soda or caustic soda may be added with advantage to the first wash waters. The film should be protected by varnish, preferably a celluloid varnish, the plate being heated previously to as high a temperature as the hand can bear to thoroughly dry the gelatine. A better protection is a cover-glass cemented on with Canada balsam. On no account should any printing paper be allowed to touch the unprotected film. So as not to rely entirely on the silver, platinum or carbon prints should be taken; the author considers platinum more trustworthy as to permanence. G. H. B.

1054. *Measuring the Curvature of a Reflecting Surface.* **R. Dongier.** (Soc. Franç. Phys., Bull. 161. pp. 3–4, 1901.)—The apparatus consists of a cross wire which is strongly illuminated by a light placed behind it; the light then falls on the surface under examination and is reflected through a lens, finally being brought to a focus and forming an image of the cross wires in the field of a microscope. The object under examination is placed on a movable platform, the extent of the movement of which can be easily observed. This instrument is said to give more accurate results than the spherometer. It is also applicable to the study of any optical system whatever, whether convergent or divergent. [A fuller account appears in the Journ. de Phys. 10. pp. 266–276, April, 1901.] W. C. O.

1055. *Sharpness of Sight.* **A. Broca.** (Soc. Franç. Phys., Bull. 159. p. 2, 1901.)—Sharpness of sight of unit value is defined by the analysis of detail in an object viewed under an apparent angle of 1′. Visual sharpness is augmented from 0·65 to about 0·81 by adaptation, when the illumination is about 1 candle-metre. The author studied the visual sharpness when the ratio I/I′ of illumination of closely adjoining patches varied. For values of I/I′ comprised between 0 and 0·08, adaptation produces no variation. From 0·08 to 0·15 the sharpness changes from 1·0 to 0·9. At 0·6 it falls abruptly when I is, say, 40 candle-metres. The curve of variation of visual sharpness as a function of the intensity for $I'/I = 0{\cdot}6$ shows that it begins to diminish at three or four times the intensity at which the decrease sets in for $I'/I = 0$. This explains the considerable effect of adaptation for seeing details in radioscopy. Studying by means of Masson's disc the effect of making I′/I tend towards the discernible limit, the author found that the sensibility increases until the patches are seen under an angle of 15′ to 20′. The decrease of sensibility is very slow between 15′ and 9′, and then becomes very rapid. E. E. F.

1056. *Interferometer Curves.* **J. C. Shedd.** (Phys. Rev. 11. pp. 304–315, 1900.)—The author describes several new operations with Michelson's refractometer. One of them is that of finding the chromatic fringes (zero position) without any previous acquaintance with the instrument. Having secured fringes with the sodium flame in the usual manner, the movable mirror is run out 6 or 7 mm. and adjusted to minimum parallax. This will give a small value

to the angle between the fixed mirror and the reflection of the movable one. The latter is now advanced through the zero position until the curves are hyperbolæ. The motion is finally reversed and the movable mirror is allowed to recede until the fringes just begin to become circular. If, now, white light be substituted for the sodium flame, and the movable mirror be made to slowly recede by means of the tangent screw, chromatic fringes quickly appear. So distinct are they that the diffused light of the room is sufficient to bring them out very clearly. E. E. F.

1057. *Dispersion Formulæ.* **L. Gorczyński.** (Phys. Zeitschr. 2. pp. 205–211, Jan. 5, 1901.)—The author discusses the formulæ of Cauchy, Schmidt, Ketteler, Wüllner, Hartmann, and Lommel. The latter is the best for making up tables of dispersion, especially when extrapolation is required. E. E. F.

1058. *Change of Form of Light Vibrations.* **W. Voigt.** (Ann. d. Physik, 4. 1. pp. 209–214, Jan., 1901.)—In a former paper [Abstract No. 1670 (1899)] on the propagation of plane waves of not quite periodic frequency in an infinite, absorbing and dispersing medium, the equation—

$$\frac{\partial^2 u}{\partial t^2} = a^2 \frac{\partial^2 u}{\partial z^2} - 2b \frac{\partial u}{\partial t}$$

was established. In the integration of this equation an error had been made which the present note corrects. It is shown that the expression finally arrived at leads to the same results as before, viz., the beginning of a motion of the plane $z = 0$ is propagated with the same velocity as if the medium were not an absorbing one: the end of the motion is not propagated at all, an after effect due to past excitation remaining and only disappearing after an infinitely long time, and the vibration form changes during propagation. G. E. A.

1059. *Pressure of Light.* **P. Lebedef.** (International Physical Congress at Paris, Report, 2. 133–140, 1900.)—Maxwell's pressure in the ether, in a direction normal to the waves and numerically equal to the energy per unit of volume, and equal for bright sunlight to the weight of 0·4 mgr. per square metre of black absorbent surface and 0·8 mgr. per square metre of mirror, is experimentally demonstrated by a method designed to eliminate thermal and radiometric causes of error. There remains always a pressure which is, in amount, that predicted by the theory. Let such a pressure act upon the head of a comet; the larger stones would be little affected, those of smaller and smaller size down to 1 cm. would be more and more repelled by the pressure of the light, and the very fine dust would be repelled. The head of the comet would thus be spread out. A. D.

1060. *Investigating the Polarisation of Ultra-violet and other Light.* **W. Voigt.** (Phys. Zeitschr. 2. pp. 303–306, Feb. 16, 1901.)—The method is being used with satisfactory results in an investigation of optical constants of some of the metals. In addition to an analyser (Nicol, or plane mirror), two double wedges of quartz are required. The first of these consists of two equal wedges cut perpendicular to the optic axis, one from a right-handed, the other from a left-handed crystal. The second consists of two equal wedges cut *parallel* to the optic axis, and having their edges parallel and perpendicular respectively to the axis. The wedges of each pair are cemented

together so as to form a plate. The two plates are placed one behind the other, the edges of the first pair of wedges being at right angles to those of the second pair. When the polarised light transmitted through the combination is observed with the analyser, a system of dark spots is seen, and these spots move along parallel lines when the analyser is revolved. It is found most convenient to use photography, small light spots appearing on the negative corresponding to the black spots above mentioned. Their rectangular coordinates can be measured with considerable accuracy, and the author explains how the state of polarisation of the incident light can be deduced from these co-ordinates. By using quartz lenses with Nicol prisms, the method can be applied nearly as far as wave-length 0·3 μ. The greater portion of the paper is occupied by a mathematical discussion, and the writer announces that a more extended account will be published elsewhere.

A. E.

1061. *Action of Salts upon Rotatory Power of Sugars.* **J. de Kowalski** and **P. Tomartschenko.** (Archives des Sciences, 11. pp. 294–299, March, 1901.)—In general the rotatory power of saccharose diminishes in presence of halogen salts, the more so as the concentration of the salt increases. The amount of the diminution and the molecular weight of the salt are related, but are not, as Farnsteiner thought, inversely proportional to one another. The diminution of rotatory power produced by a salt is greater the less dissociated the salt, and the power of producing such diminution is greater the less the power of dissociating. NaCl, KCl, and LiCl produce an increase of the lævo-rotatory power of invert sugar. The dextro-rotatory power of glycose is diminished by salts, but to a smaller extent than in the case of saccharose. In glucose bi-rotation may be eliminated by adding a drop of a very weak solution of ammonia and heating the solution for some hours to 65°.

A. D.

1062. *Influence of Solvents on the Rotation of Optically Active Compounds.* **T. S. Patterson.** (Chem. Soc., Journ. 79. and 80. pp. 167–216, Feb., and pp. 477–493, April, 1901.)—Part I. *Influence of Water, Methyl-, Ethyl-, and n-Propyl-Alcohols, and Glycerol on the Rotatory Power of Ethyl Tartrate.*—The author gives the results of a large number of experiments made to determine the influence of the above-named solvents on the rotation of ethyl tartrate at various concentrations and temperatures. From the numbers obtained curves have been constructed showing for each solvent the connection between (1) the specific rotation of the ester and the temperature for solutions of different concentrations, and (2) the specific rotation and the concentration at 20°. In dilute solutions the solvent exerts its greatest influence, and in these a gradual variation is found to occur (1) in the value of the specific rotation, which decreases as the molecular weight of the solvent increases; (2) in the form of the rotation-concentration curves, those for water and methyl alcohol being concave towards the axis of concentration while in the case of ethyl alcohol there is a slight convexity which is more marked for propyl alcohol and still more so for glycerol; (3) in the effect of increase of temperature upon corresponding solutions. In water the temperature coefficient of the rotation is negative, in methyl alcohol positive and slightly less than for the pure ester, in ethyl alcohol the same as for the pure ester, whilst for *n*-propyl alcohol it has a distinctly higher value. The author then discusses the results with a view to correlating the variation in rotation with some similarly variable physical property of the dissolved substance, the

solvent or the solution. He suggests that the requirements of such a property are met by what is known as the "internal pressure" of the solvent. The data obtained by the author render possible the calculation of the molecular solution volume (M.S.V.) between which and the rotation a regularity is found to exist, the variation of rotation with change of temperature being readily explained by certain assumptions regarding the way in which the asymmetry of the molecule changes with change of its volume. Connection is then traced between the rotation and the internal pressure or, what is probably the same thing, the heat of disgregation, and in this case also regularities are found to exist, indicating that the assumptions made as to the dependence of solution volume on internal pressure and of rotation on both of these, are justified. The following table contains a summary of the relationships discussed by the author :—

Solvent.	$[\alpha]_D^{20°}$ Infinite Dilution.	Association Factor of Solvent.		M.S.V. of Ethyl Tartrate. Infinite Dilution, 20°.	Heat of Disgregation of Solvent, 60°.	Dielectric Constant of Solvent.
		Ramsay and Shields.	Traube 15°.			
Water	+ 26·2°	1·644 (20°)	2·3	157·7	523·1	80
Methyl alcohol..	11·5	2·32 (20°)	1·79	159·3	248·6	32
Glycerol	10·6	—	1·90	163·3	—	56·2
Ethyl alcohol ...	9·1	1·65 (20°)	1·67	164	201·6	26·1
n-Propyl alcohol	7·4	2·25 (46·3°)	1·66	167·5	175·2	22

Part II. *Influence of iso-Butyl Alcohol and sec-Octyl Alcohol (Methylhexylcarbinol) on Ethyl Tartrate.*—Measurements of the rotation of ethyl tartrate in iso-butyl and sec-octyl alcohols show that the rotation continues to diminish as the molecular weight of the solvent increases. As will be seen from the numbers given in the following table, which refer to 20°, the molecular solution volumes obtained with these solvents confirm the results obtained with the lower alcohols ; so long as the diminution of rotation continues in passing from one solvent to another, so long also does the molecular solution volume increase and the decrements of rotation correspond fairly closely with the increments of volume.

Solvent.	M.S.V. Infinite Dilution.	Δ	$[\alpha]_D$ Infinite Dilution.	Δ	Change in $[\alpha]_D$ due to Solution.
Methyl alcohol	159·3 c.c.		11·50°		3·84°
Ethyl ,,	164·0	4·7 c.c.	9·13	2·37°	1·47
n-Propyl ,,	167·5	3·5 c.c.	7·40	1·73	— 0·26
iso-Butyl ,,	170·3	2·8 c.c.	6·53	0·87	— 1·23
sec-Octyl ,,	174·3	4·0 c.c.	5·24	1·29	— 2·52

It will also be noticed that the changes in volume and rotation appear to become simultaneously smaller and probably both tend to limiting values, which are, however, not the constants for free ethyl tartrate. T. H. P.

1063. *Magnetic Optical Dispersion in Negatively Rotating Salt Solutions. Potassium Ferricyanide.* **L. H. Siertsema.** (Archives Néerlandaises, 5. pp. 447-452, 1900.)—In the case of titanium chloride and ferric chloride

solutions, which deviate from the general rule stating that the magnetic rotation of the plane of polarisation is in the same sense as the magnetising current, it has been shown by Becquerel that the amount of their negative rotation is proportional not to $1/\lambda^2$, but to $1/\lambda^4$. The author gives results of a number of measurements of the dispersions, for different pairs of wave-lengths, of the magnetic rotation of a solution of potassium ferricyanide containing 1 gramme of salt per 100 grammes of solution; the numbers show that the dispersion is much greater than would correspond with proportionality between the rotation and $1/\lambda^4$. T. H. P.

1064. *Optical Constants of Quartz.* **J. M. de Lépinay.** (Journ. de Physique, 9. pp. 644–652, 1900.)—The author has applied his half-shadow analyser [see Abstract No. 789 (1901)] to the determination of the characteristic constants of the rotatory power and birefrangence of quartz for the green ray of mercury of wave-length 0·54607424 μ. The rotatory power of quartz, 1 cm. thick, at 0° is—

$$\alpha = 255{\cdot}171^\circ + 0{\cdot}0046^\circ\,(t - 15^\circ).$$

The new and accurate figures obtained make Mouton's method of measuring thicknesses reliable and convenient. E. E. F.

1065. *Theories and Formulæ of Dispersion.* **E. Carvallo.** (International Physical Congress at Paris, Report, 2. pp. 175–199, 1900.)—An historical sketch is given including the theories of Cauchy, Briot, Boussinesq, Sellmeier, O. E. Meyer, Helmholtz, Lommel, Ketteler, and Poincaré. Near the end of the paper the author proposes the new formula,

$$n^2 = \gamma'\lambda^4 + \gamma\lambda^2 + \alpha + \frac{\beta}{\lambda^2} + \beta'\frac{n^2}{\lambda^2},$$

where λ denotes wave-length in vacuo, n index of refraction, and the other quantities represent constants. A. E.

1066. *Interferometer Study of Zeeman Effect.* **J. C. Shedd.** (Phys. Zeitschr. 2. pp. 278–283, Feb. 9, 1901.)—The author gives an account of his study of the Zeeman effect by means of Michelson's interferometer. His method depends upon drawing the "visibility" curves, taking for ordinate the intensity of the fringes and for abscissa the difference of path of the interfering rays (Michelson, Phil. Mag. 13. 338, 1891), and he shows how, by means of these, the broadening, multiplication and polarisation of the lines can be studied. He gives four methods for the measurement of the change of wave-length, the second alone being applicable for observations perpendicular to the direction of the magnetic field. In the first method, used by Michelson, which is a good one if the difference of wave-length is not very small, the distance between two successive maxima in the curve is measured. In the second, when observation is made perpendicular to the direction of the magnetic force, the middle component is cut out by a Nicol prism and the position sought such that the systems of fringes arising from the two other components touch one another. In the third method one of the systems is extinguished and a position obtained such that the centre of the field is dark or bright according as the magnetic field is not or is excited. In the fourth method a position is obtained such that a given line is tangential to each set of fringes when the other is cut off. The author, in conclusion, compares the determined breadth of the equivalent simple light sources with the differences of

wave-length, and claims to obtain results which are satisfactory and which confirm the validity of the methods employed. [See further Abstract No. 625 (1900).] W. E. T.

1067. *Dispersion of Fluorspar.* **F. Paschen.** (Ann. d. Physik, 4. 2. pp. 299–303, Feb., 1901.)—Measurements of the dispersion of fluorspar in the infra-red were made in order to test the usefulness of Ketteler's formulæ. The range of wave-lengths extended from $\lambda = 0{\cdot}8840\,\mu$ to $7{\cdot}0718\,\mu$. The formula agreeing best with the results was—

$$n^2 = A^2 - \frac{M_2}{\lambda^2 - \lambda_2^2} - k\lambda^2 - l\lambda^4,$$

with $A^2 = 2{\cdot}03913$, $k = 0{\cdot}0032055$, $n = 0{\cdot}000002894$, $M_2 = 0{\cdot}006125$, and $\lambda_2^2 = 0{\cdot}{\cdot}08884$. E. E. F.

1068. *Unsymmetric Alteration of Spectrum Lines in a Magnetic Field.* **P. Zeeman.** (Archives Néerlandaises, 5. pp. 237–241, 1900.)—The author was able to compare more closely the effects on light of magnetic fields of different strengths by employing an extended source of light, whose different parts were subject to different magnetic forces. In order to avoid the astigmatism of the image in Rowland's apparatus, he made use of the arrangement of Runge and Paschen [Abstract No. 24 (1898)], in which he shows that the observer looking along the normal to the grating obtains a stigmatic image. This involved, however, focussing afresh for each part of the spectrum. He believes that he could observe directly a difference in the intensity of the outer components of the D_1 line in the direction required by theory (Voigt, Drude's Annalen, 1. p. 376, 1900). Removing by a Nicol the central components of the blue and green zinc and cadmium lines, he could observe directly the want of symmetry in the intensity of the remaining components. W. E. T.

1069. *Spark Spectrum of Silicon.* **W. N. Hartley.** (Roy. Soc., Proc. 68. pp. 109–112, March 25, 1901.)—This paper is in answer to a remark by Lunt that the early work of Hartley and Adeney, and Eder and Valenta only referred to the more refrangible portions of the spectrum. Reference to the 1883 photographs shows that the least refrangible line of silicon is at λ2881·0, and no trace of any between λλ4573 — 4553, where the triplet occurs as found by Lunt.

Some remarks are also made on the interaction of the other substances present in influencing the relative intensity of the sodium and carbon lines found on the plates. C. P. B.

1070. *Radiation of Gases.* **E. Pringsheim.** (International Physical Congress at Paris, Report, 2. pp. 100–132, 1900.)—This address contains a review of the literature on the emission and absorption of gases. The conclusions arrived at are the following :—

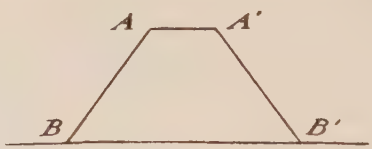
(1) True calorific radiation (where the conditions of Kirchhoff's law are completely fulfilled) very probably takes place in the continuous spectra and the band spectra of gases and vapours, which emit these spectra at high temperatures, such as H_2O, CO_2, I, Br, Cl, S, Se, As, Na, K, Li, Tl. (2) When these continuous and band spectra emanate from flames the emission is partly due to chemical transformations, and consequently Kirchhoff's law does not apply. (3) Kirchhoff's law does not apply to the line and band

spectra of fluorescent gases. (4) The same is the case for spectra produced by the electric discharge. These owe their origin not to the high temperature but to electric phenomena, and possibly to complicated chemical transformations. (5) At all the temperatures which have up till now been experimentally attained, no gas emits a line spectrum solely due to the temperature. This spectrum only occurs under the action of particular phenomena (chemical, electrical). (6) Gases can emit continuous and band spectra by simple rise of temperature. Whether or not line spectra also might be obtained by a sufficiently high temperature cannot yet be affirmed. (7) In all sources of radiation in which chemical or electrical phenomena are present it seems that the law of Kirchhoff does not apply.

As these phenomena are very probably present in the luminous stars, one ought not to apply the law to problems in physical astronomy.

The report concludes with some theoretical considerations as to what particles (atoms, molecules, or electrons) in a gas the spectral radiation is due. J. B. H.

1071. *An Optical Illusion.* **J. Drecker.** (Phys. Zeitschr. 2. pp. 144–145, 1900.)—Wind's supposed discovery of the diffraction of Röntgen rays has since been explained as an optical illusion [see Abstract No. 1647 (1900)]. The illusion can be produced by letting a rectangle be illuminated across a



breadth AA′ with uniform brightness, and flanking each side with patches AB, A′B′ of uniformly diminishing brightness (see diagram, where the ordinates represent brightnesses).

A dark fringe then appears in the centre of AA′. On cutting off AB, A′B′, the portion AA′ again appears uniformly illuminated. E.-E. F.

1072. *De-ionisation of Air.* **E. Villari.** (Phys. Zeitschr. 2. pp. 360–361, March 16, 1901.)—Villari found [Abstract No. 1803 (1900)] that air, previously ionised by Röntgen rays, was de-ionised by passing it over a metallic surface, and that the latter thereby became charged. Dorn [see Abstract No. 800 (1901)] suggested an explanation based on the differences which, according to Zeleny, exist between the velocities of the positive and negative ions. If Zeleny's results are correct, moist ionised carbon dioxide should impart a charge of opposite sign to that imparted by other gases.

Villari finds that this is not so. For example, moist ionised carbon dioxide passing over iron gave the latter a negative charge, and so also did moist ionised air—the only difference being that the electrometer deflection was twice as great for air as for carbon dioxide. D. E. J.

1073. *Duration of Emission of Röntgen Rays.* **B. Brunhes.** (Soc. Franç. Phys., Bull. 163. pp. 1–3; Discussion, pp. 3–4, 1901.)—The author refers to his experiments already published [see Abstracts Nos. 828 and 1801 (1900)] and describes further experiments. He finds that the emission of Röntgen rays lasts for a finite time, the duration being of the order of $\frac{1}{100000}$ to $\frac{1}{1000000}$ of a second. In one experiment he connects a spark-gap and the Crookes

tube in series with the secondary of an induction coil, and finds that while the spark always gives on a screen as clear and distinct images of a hole in a disc revolving rapidly as when the disc is at rest, thus showing it to be instantaneous, the Crookes tube, on the other hand, gives throughout a single image on the fluorescent screen. He accounts for the phenomenon by saying that the exact instant at which the spark passes is that at which the gaseous molecules strike the kathode in the Crookes tube. It is only afterwards that these molecules are repelled by the kathode, and this flux of kathode rays, spreading out and creeping to the anti-kathode, strikes it during a finite time.

In the discussion **P. Villard** said the experiments described confirmed his own experiments on the duration of the emission of kathode rays, if we suppose the transformation of these rays into Röntgen rays to be instantaneous at the moment of striking. Thus the duration of emission of the Röntgen rays would be really that of the kathodic emission. **Colardeau** described experiments he had made, but not yet published, to show that the effects vary greatly according to the arrangement of the discharge circuit of the coil. If the Crookes tube is connected up directly to the terminals of the secondary it is traversed by several consecutive discharges even with a single interruption of the primary circuit. This was shown by directing the Röntgen rays on to a photographic plate revolving rapidly round an axis perpendicular to its plane, and interposing between the tube and the plate a piece of metal with a straight slot cut in it. Instead of a single image, a series of images was obtained, somewhat resembling the solar spectrum spread round the sector of a circle. But if a spark-gap is introduced into the circuit and the poles of the secondary shunted by a condenser of sufficient capacity to make the whole discharge take place in a single passage through the tube, the photographic plate shows only a single image of the slot, and this image is as clear as that given when the plate is at rest. A duration of about $\frac{1}{30000}$ of a second would have given a very noticeable enlargement of this image, and the speaker therefore concluded that the true duration of emission of Röntgen rays by a single discharge would be under this limit. In his reply to the discussion **B. Brunhes** maintained that in the conditions under which he had worked there was a clear difference of speed between the emission of the Röntgen rays and the spark in series with the Crookes tube, the former lasting $\frac{1}{10000}$ of a second while the spark was instantaneous. His photo left no doubt on this point. W. C. H.

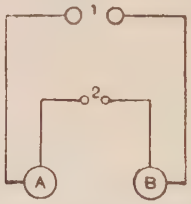
1074. *Transparency to Röntgen Rays.* **L. Benoist.** (Comptes Rendus, 132. pp. 324–327, Feb. 11, 1901.)—Having shown that the absorbing power or specific opacity of a body increases with the density and that all bodies exercise a selective absorption on Röntgen radiation, the author extends his researches to 120 bodies tested under the most varied conditions. Taking for his standard the absorption exercised by a block of paraffin 75 mm. thick and calling the equivalent transparency of a body the mass, in decigrammes, of a prism 1 square cm. base which produces the same absorption as his standard, it is found :—(1) The specific opacity of a body is independent of its physical state, *e.g.*, it is the same for water as for ice. (2) The opacity is independent of the mode of atomic grouping, *e.g.*, of crystalline form, allotropic state, &c. (3) It is independent of the state of liberty or combination of the atoms; thus the equivalent transparency of a combination can, with certain limitations, be calculated from the transparencies of its constituent elements. It is found, plotting atomic weights as abscissæ and the equivalent transparencies as ordinates, that these points lie on a regular hyperbolic curve. If, however,

the character of the radiation is altered, either by altering the tube or interposing an absorbent screen, the same hyperbola is not obtained ; from a study of these curves the fourth result is obtained, viz., (4) The specific opacity of simple bodies, measured under well-defined conditions, is a definite function of their atomic weight and increases with the latter, the proportionality being nearly direct for rays of the most penetrating kind. R. S. W.

1075. *Radio-activity of Matter.* **H. Becquerel.** (Nature, 63. pp. 396–398, Feb. 21, 1901.)—A historical summary. It appears that even the radio-activity of uranium is due to traces of some radio-active substance. A. D.

1076. *Transparency to Radium Rays.* **T. Mizuno.** (Electrician, 46. p. 399, Jan. 4, 1901.)—The differences in the transmission of radium rays through various substances may be readily shown by a spark method (see diagram).

To each of the poles A and B of an induction coil were respectively attached two wires forming the alternative spark-gaps 1 and 2, as shown in the annexed figure. These spark-gaps were formed by spark micrometers, so that the spark-lengths could be finely adjusted at will. Now suppose that one of the spark-gaps, say 1, is drawn apart just beyond its critical spark-length,



that is to say, such a length across which the spark is just unable to spring, whilst the other spark-gap 2 is disposed just below its critical length. In this sensitive state of the spark-gaps, if we bring the radium preparation into the neighbourhood of the gap 1 vivid sparks will take place there, while the sparks in the gap 2 will be either very much enfeebled or completely annihilated. On bringing layers of various substances between the gap 1 and the radium preparation, the sparks passed the gap as long as the layers did not exceed a certain thickness, varying from one substance to another. E. E. F.

1077. *Secondary Radio-activity of Metals.* **H. Becquerel.** (Comptes Rendus, 132. pp. 371–373, Feb. 18, 1901.)—A block of lead 34 mm. long, 21 mm. wide, and 7 mm. high, has a groove cut in it 1·6 mm. deep, and in this is placed a layer 1 mm. thick of a salt of radium possessing strong radio-activity. After being eleven months in this position, salt and block are placed on a photographic plate wrapped in black paper and after an exposure of forty-eight hours the plate is developed. An intense impression is obtained, not only beneath the block, but at some distance from the lateral walls, in which case the radiation has traversed a thickness of lead varying from 12 mm. to 20 mm. This radiation is very penetrating, affecting each of three photographic plates placed one on the other. These effects are not due to vapour emitted by the metal, for a sheet of mica interposed between the block and the plate does not hinder their production. If particles of metal are placed on the plate at varying distances from the block, then, after the same exposure, it is found that each particle has affected the plate more

strongly than the direct radiation has done. On the side exposed to the source there is an intense secondary emission ; on the side more remote only the effect of the direct radiation appears, and another particle in the shadow of the former shows no secondary effects. The secondary radiation is easily absorbed, and the metallic fragments lose their activity when cut off from the exciting source. R. S. W.

1078. *Luminescence of Organic Compounds.* **R. Dubois.** (Comptes Rendus, 132. pp. 431–432, Feb. 18, 1901.)—The author finds that a number of essences, including otto of roses, become luminous when acted upon by cold alcoholic potash. The most marked result, however, was obtained with the glucoside æsculin, the luminescence of the alcoholic potash solution being in this case instantly destroyed by the addition of water. T. H. P.

REFERENCES.

1079. *Stroboscopic Phenomena.* **C. Barus.** (Science, 13. pp. 128–129, Jan. 25, 1901.)—Note on an appearance seen when the shadows of the revolving bars of a squirrel-cage are thrown on a near screen parallel to the bars. A. E.

1080. *Crookes Tubes for Radiography.* (Archives d'Él. Médicale, 9. pp. 36–37, Jan., 1901.)—A form of tube is described in which the anti-kathode is kept from unduly heating by being backed by a substantial copper rod. A. D.

1081. *Infra-red Spectrum.* **H. Rubens.** (International Physical Congress at Paris, Report, 2. pp. 141–174, 1900.)—This paper furnishes a detailed historical summary of the investigations which have been made concerning the infra-red spectrum, commencing with Herschel's observation of 1800 ; the author describes the various instruments which have been employed in the determination, the dispersion formulæ for the reduction of observations, and the method of graphically plotting out the spectrum from the bolometric records. C. P. B.

1082. *Distribution of Spectrum Lines.* **J. R. Rydberg.** (International Physical Congress at Paris, Report, 2. pp. 200–224, 1900.)—A *résumé* of the work which has been done in the way of classifying the spectra of the elements, and arranging their lines in series. Tables and curves are given illustrating conclusions deduced from the results. The report includes a classified index to the literature of the subject. Line spectra are provisionally classed under the headings type I., and type II. ; type I. comprising those spectra which can be resolved into sets of infinite series of lines converging to finite limits ; type II. those which cannot, though in this case the lines can be arranged in rows and columns which exhibit constant differences of wave-number. The results of research into the constitution of spectra of type I. are summed up in some comparatively simple laws. Banded spectra, and line spectra of type II. have not yet been sufficiently investigated to permit of a comparison between the different elements. A. E.

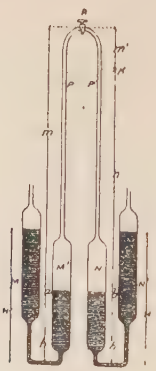
1083. *Theoretical Laws of Radiation.* **W. Wien.** (International Physical Congress at Paris, Report, 2. pp. 23–40, 1900. —The points treated in this report are as follows : Kirchhoff's law, Temperature of radiation, Wien's paradox [see Abstract No. 71 (1901)] Boltzmann's thermodynamic proof of Stefan's law, also another proof of the same, the thermodynamic proof of Wien's formula for the partition of energy in the spectrum of a black body, and a discussion of Planck's deduction of the same formula from the electromagnetic equations representing the oscillations of an electric dipole. J. B. H.

HEAT.

1084. *Thermal Conductivity of Air.* **E. Müller.** (Phys. Zeitschr. 2. pp. 161–165, 1900.)—The author shows that the coefficient of thermal conductivity of air increases more slowly with the temperature than does the coefficient of viscosity. Kundt and Warburg's thermometer-bulb method is not suitable for absolute measurements. E. E. F.

1085. *Specific Heat of a Gaseous Mixture of Bodies in Chemical Equilibrium.* **A. Ponsot.** (Comptes Rendus, 132. pp. 759–761, March 25, 1901.)—If there are two systems in chemical equilibrium, that which by its formation increases the volume of the mixture and which displaces the other when the volume increases is also that into which the gaseous mixture tends entirely to pass when the temperature increases without limit, whether at constant pressure or at constant volume. Its formation increases the specific heat of the mixture, and this increase is larger for constant pressure than for constant volume. R. E. B.

1086. *Boyle's Law at Very Low Pressures.* **A. Battelli.** (N. Cimento, 1. pp. 5–40, Jan., and pp. 81–111, Feb., 1901. Phys. Zeitschr. 2. pp. 409–411, April 6, 1901.)—The author's method eliminates various sources of error attaching to previous investigations, or determines their amount. The apparatus consists essentially of two cylinders of glass or iron, com-



municating with each other and with a special micromanometer. A compression pump, communicating with one of the cylinders from below, brings the mercury to the level of two marks, one at the lower end and one at the upper end of the cylinder. All the parts may be connected with a set of desiccating tubes furnished with hygroscopic wadding. When the mercury stands at the lower mark, the air pump is worked until the pressure desired is obtained. When the pressure has been read off, the mercury is made to rise to the upper mark. When the charge of volume is known, and the charge of pressure and the temperature of the apparatus are determined, all the necessary figures are given. The substitution of iron for glass was made in order to determine the disturbing influence of absorption by the cylinder walls.

The author used a delicate micromanometer of the form shown in the diagram. M, M′, N, N′ are four cylindrical vessels of the same shape and volume. R is a three-way cock used for filling. M and N′ are connected with the compression apparatus by perfectly fitting cocks and contain mercury which rises to *a* and *b* in M′ and N. M′ contains water, which reaches as far as K. The rest of the tube and N contain aniline, the two liquids having a very slight difference of density. The displacement of the meniscus indicates differences of pressure as low as 0·001 mm. of mercury. The results show that air has a deviation from Boyle's law between 2 and 5 mm., and another at about 0·1 mm., the latter being, however, somewhat uncertain. Hydrogen obeys the law down to 0·02 mm. Oxygen shows a break at 0·7 mm. Carbon dioxide shows greater compression than it should show at very low pressures, but that may be due to an undiscovered absorption by the walls of the vessel.

E. E. F.

1087. *Thermodynamical Properties of Superheated Steam and the Dryness of Saturated Steam.* **J. H. Grindley.** (Manchester Lit. and Phil. Soc., Mem. 45. 3. pp. 1–11, 1900–1901.)—For superheated steam, (1) the author draws up from his former experimental results [Abstract No. 1436 (1900)] a table of the total heat of its formation at different pressures and temperatures from water at 32° F.; (2) by utilising Ramsay and Young's experiments he calculates the values of the isopiestic specific heat for temperatures between 290·3° and 426·5° F.; these, compared with the values formerly found by employing Regnault's linear relation between the total heat of saturated steam and the temperature, throw doubt on this relation; (3) he finds that for adiabatic change between 1 and 5 atmospheres and 210° and 330° F. the values of pv^n are constant when $n = 1{\cdot}286$; (4) he shows that the product of the isopiestic specific heat and the cooling effect on expansion is D/a^2 for pressure p, where $D = 1{\cdot}625$ and $a = 1{\cdot}000023$ when p is measured in lbs. per square foot.

For dry saturated steam the specific volumes deduced from Ramsay and Young's experiments and those lately given by Callendar agree in differing from those obtained from Regnault's values for the latent heat by amounts varying from 1·33 per cent. under 1 atmosphere to 3·4 per cent. under 21 atmospheres in excess, thus apparently showing that Regnault's values for the latent heat are too small by these percentages. R. E. B.

1088. *Characteristic Equation of Fluids.* **D. Berthelot.** (Archives Néerlandaises, 5. pp. 417–446, 1900.)—An excellent *résumé* of the modifications of van der Waals' equation which have been suggested and of the results deducible from them, with special stress on the principle of corresponding states. [See also Abstract No. 842 (1900).] R. E. B.

1089. *The $t\phi$-diagram.* **L. Marchis.** (Comptes Rendus, 132. pp. 671–673, March 18, 1901.)—The heat absorbed in any process is $\int t d\phi$ only when the process is reversible, or the system free from viscosity or friction. Thus areas on the $t\phi$-diagram cannot represent the heat absorbed or given out by a steam engine, as of late has very often been assumed; for, even if during expansion and compression the steam may be taken to be of the same temperature throughout, it certainly is not so during admission and exhaustion. Still less can a $t\phi$-diagram be employed in the case of a gas-engine, in which irreversible explosions also occur. R. E. B.

SOUND.

1090. *Speaking Flames.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 325–328, Feb. 23, 1901.)—Flames other than the electric arc will produce sound, relatively weak, under the influence of periodic variations of electric current. With a Bunsen burner connect the microphone circuit with the low voltage coil of a transformer; lead the current in the secondary coil to the Bunsen burner, through the flame, and back through a strip of platinum foil in the flame. In order to preserve timbre, the lamp-current I_2 should be independent of n the frequency. In order that I_2 may be a maximum, so as to promote loudness, it must be proportional to the variations of resistance in the microphone, to the microphone current, to the coefficient of mutual induction, and to the frequency n, and inversely proportional to the resistances in the primary and secondary circuits. Higher tones are therefore better transmitted than lower. For maximum loudness the self-induction coefficients must be in the ratio of the square roots of the number of windings; and the number of windings of the two coils must be in the ratio of the square roots of their resistances or, practically, in the ratio of the square roots of the microphone circuit and lamp-circuit resistances. This explains why if we increase the lamp-current by diminishing the resistance, the loudness falls off. The author uses with success in reproducing speech loudly with an arc-lamp a transformer with $2\frac{1}{2}$ times as many windings in the secondary as in the primary; the lamp working at 110 volts and about 10 amperes. With the Bunsen burner, since the resistances are greater, the secondary coil must have a correspondingly greater number of windings. It is of advantage, therefore, to have a transformer in which the ratio of turns is adjustable. This may be effectively done by passing the main current through a coil with core and passing the microphone current through an adjustable smaller number of turns of the same coil; in which construction the resistance of the coil may be so determined that there is no need of a separate microphone battery. An arrangement of several microphones is described, each with its own transforming coil, to enhance the microphone current; applicable also to loud-sounding telephone work. Remarks are made on the use of selenium cells for phototelephony, and even for working the high-resistance writing needle of a telegraphone. A. D.

1091. *Manometric Flame applied to Telephone.* **L. W. Austin.** (Phys. Rev. 12. pp. 121–124, Feb., 1901.)—Method described of photographing a manometric flame actuated by the movements of the diaphragm of a telephone receiver. The lower line of the luminous part of the flame follows quite accurately the motions of the diaphragm. The rise in the top of the flame is, with oxy-coal-gas, sensibly proportional to the voltage across the terminals of the telephone; with acetylene it is somewhat more rapid than that of the voltage. A. D.

1092. *Improved Photophone.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 339–340, March 2, 1901.)—The transmitter consists of the usual telephone disc, to which is attached a lime cylinder on which a blowpipe flame plays.

The author finds this arrangement very sensitive, and also recommends the use of a carbon dust microphone instead of a selenium cell as receiver. J. E.-M.

1093. *Measuring the Vibration of a Transmitter Diaphragm.* **W. L. Merrill.** (Amer. Electn. 13. p. 67, Feb., 1901.)—The vibration of a telephone transmitter is measured by means of a ray of light reflected from a small mirror cemented to a steel pinion set in watch jewels. To the centre of the diaphragm is soldered a needle which presses on a steel arm. This arm is perpendicular to the pinion and in the plane of the mirror. The slightest vibration is transmitted through the needle and arm to the mirror, causing it to oscillate and thus deflect the beam of light. In an experiment a diaphragm excursion of one three-thousandth of an inch deflected the spot of light on a screen 25 feet away 2 inches. The ticking of a watch gave noticeable deflections, and loud sounds produced deflections of 2 feet. A. R.

1094. *Propagation of Sound between Parallel Walls.* **Rayleigh.** (Phil. Mag. 1. pp. 301–311, March, 1901.)—Kirchhoff treated the influence of viscosity and conduction of heat on the propagation of sound in a gas contained in cylindrical tubes of moderate radius, and his investigation is given in Rayleigh's Treatise on Sound (2nd edition, § 348). In the present paper Rayleigh begins with a recapitulation of Kirchhoff's theory. The condition of the gas at any point x, y, z is defined by the velocity components u, v, w, and θ' the excess of temperature : θ' is given by the equation—

$$\theta' = A_1 Q_1 + A_2 Q_2,$$

in which A_1, A_2 are arbitrary constants and Q_1, Q_2 are functions of x, y, z, satisfying the equations—

$$\nabla^2 Q_1 = \lambda_1 Q_1, \qquad \nabla^2 Q_2 = \lambda_2 Q_2,$$

λ_1, λ_2 being the roots of a certain quadratic equation.

Rayleigh passes on to the case in which two planes parallel to that of xz, namely $y = \pm r$, are substituted for Kirchhoff's cylinder. The solution obtained differs from Kirchhoff's only by the substitution of $2y_1$, the distance between the planes, for r the radius of the cylinder. So far as it depends on x, the solution is of the form $u = \epsilon^{int\epsilon - m'x - im''x}$, m' and m'' being constants depending on the coefficients of viscosity and conduction of heat.

So far as regards y, it is found that, except in the immediate neighbourhood of the walls, $u = -\dfrac{Q_1(y)}{Q_1(y_1)}$, and is approximately constant. Rayleigh then considers the value of u when y_1 is very great, and finds that *the phase* varies with y, so that constancy of phase requires that as y increases x should diminish, or the wave surface is convex towards positive x and the wave divergent.

The solution, as is pointed out by the writer, fails to answer the practical question that he himself had proposed, namely, whether in the passage of sound over smooth water there is any appreciable *shadow* formed near the surface under the influence of viscosity and heat conduction. The result is that this effect may be neglected in practice except for an observer very near the water. S. H. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1095. *Electric Inertia.* **A. Schuster.** (Phil. Mag. 1. pp. 227–238, Feb., 1901. Paper read before the Physical Society of London.)—In the immediate neighbourhood of an ion the magnetic field will be many times greater than that calculated on the supposition of continuous distribution, and hence the total magnetic energy is under-estimated. The author, proceeding on the basis of the electron theory, calculates the additional terms which become necessary for the evaluation of self-induction. He finds the excess of magnetic energy per unit length of a row of electrically charged particles to be—

$$C^2\left(\frac{1}{3an} - 0{\cdot}842\right),$$

where C is the current, a the radius of the particles, and n their number per unit length. If N is the number of electrons in unit volume, i the current density, and μ stands for $2/3\pi N$, then the correcting term per unit volume of a conductor is—

$$\frac{1}{2}\mu i^2.$$

The flow of electricity will behave as if it had inertia, the apparent mass for unit current density and unit of volume being μ. The dimensions of μ, as pointed out by Hertz, are the same as those of a surface. The author uses the expression "electric inertia" for the quantity μ; the energy due to electric inertia is the energy of the magnetic field due to the moving electrons over and above that which is calculated in the usual way. The correction to self-induction for a conductor of length l and uniform cross-section A will be—

$$l/6\mathrm{NA}a,$$

if both kinds of electrons take equal parts in conveying the current. The correcting term increases in importance with diminishing cross-section, and might be made large if the cross-section could be reduced so as to be comparable with molecular dimensions.

As regards the chances of verifying the existence of this inertia experimentally, the author calculates that the effect would be much smaller than the extreme limits of Hertz's experiments on electric inertia. In metals, therefore, no results need be looked for, but if in a bad conductor, like carbon, the distance between the moving electrons should be, say, 50 times as great as that between the molecules, we should get within the limits to which Hertz worked. In the case of liquids and gases, the chances of experimental verification of inertia are equally remote, but a clear proof of such inertia may be looked for in the domain of luminous vibrations. E. E. F.

1096. *On Certain Fundamental Propositions in Electrical Theory.* **W. H. Julius.** (Archives Néerlandaises, 5. pp. 497–505, 1900.)—The electrostatical theory due to Gauss, Laplace, and Poisson rests on the conception of action at a distance between the particles independent of the intervening medium.

This theory has to be modified with regard to Faraday's discovery that the force has different values for different media. Without an extended investigation of these phenomena, the author proposes to show in this paper that by introducing the medium at the starting-point of our theory, some difficulties which arise in the usual treatment are made to disappear.

The theory is well known by which the action of the medium as shown by experiment can be explained on the hypothesis of little conducting particles being scattered through the space in question. Increasing these until they fill the whole space, the author converts it into a conducting body, and finds that ultimately within the body $0 = \frac{4\pi}{k}\rho$, where ρ is the volume density of electricity and k the specific inductive capacity. The usual interpretation is that within a conductor $\rho = 0$. The equation would be equally satisfied by making k infinite within a conductor.

The author then considers Gauss's theorem of the "integral normal." He puts this case: A sphere has a charge σ per unit of area of its surface. The normal force ought, according to Gauss's theory, to be $4\pi\sigma$, but is in fact only $2\pi\sigma$ according to Laplace's calculation. This difficulty is due, he says, to the hypothesis which we make as fundamental, that electrically charged points can be tested in the same way as mass under the law of gravitation. We should, he says, regard the surface charge on the sphere as consisting of two equal layers, of which only one side affects the field on the outside of the sphere. If the charged sphere had a concentric conducting spherical shell surrounding it and connected to earth, every element of that shell subtending a solid angle ds at centre would have an induced charge $-\sigma$, corresponding to σ on the corresponding element of the inner sphere. It is a property of the theory advocated by the author that the force which urges outwards the charge $+\sigma$ on the inner sphere might be ascribed to the attraction exerted by the charge $-\sigma$ on the outer shell, whereas in the ordinary theory the spherical shell, having uniform density $-\sigma$, would have constant potential at all internal points, and so emit no attractive force on the internal charged sphere. S. H. B.

DISCHARGE AND OSCILLATIONS.

1097. *Conditions for Electric Discharges.* **K. R. Johnson.** (Écl. Électr. 26. pp. 393–403, March 16, 1901.)—The initiation of an electric discharge is usually admitted to depend upon (1) the difference of potential of the electrodes; (2) the form and dimensions of the electrodes; (3) their distance apart; and finally (4) the nature, pressure, and temperature of the gas in which the discharge must pass.

To these Jaumann has added a fifth condition, viz., *the variation of the magnetic field.* This has been contradicted by some physicists; the present paper mathematically discusses recent experiments and supports Jaumann's view of the matter. E. H. B.

1098. *Sparking Distance.* **W. J. Humphreys.** (Phys. Rev. 11. pp. 79–83, 1900.)—The outer coatings of two Leyden jars are connected together, and the inner coatings are connected respectively to the poles of a Wimshurst machine. The inner coatings are therefore oppositely charged. If the distance between the discharging balls is diminished to nearly the disruptive spark length, a glass rod brought up to the positive ball at the part of it facing the negative will generally cause disruption and allow a noisy

spark to pass. But nothing of the kind happens when the rod is placed next to the negative pole, or, in fact, in any part of the field other than that very near the anode. Various kinds of dielectric have yielded the same results; the phenomenon can be shown by a silk thread stretched taut and approximately at right angles to the field. R. A.

1099. *Currents in Lightning Conductors.* **F. Pockels.** (Phys. Zeitschr. 2. pp. 306–307, Feb. 16, 1901.)—The author has previously shown that the residual magnetism of basalt depends only on the maximum magnetising field to which it has been exposed. This fact is here utilised to gauge the current in a lightning conductor. The experimental method consists in placing a basalt bar crosswise near the lightning conductor and testing it after a lightning discharge has passed. The expression connecting current and the other quantities concerned is given thus :—

$$i = \frac{5l}{2\tan^{-1}\left(\frac{l}{2a}\right)} \mathrm{H} ;$$

where i is the current in amperes, l the length of the basalt bar, a the distance of its middle point from the axis of the lightning conductor, and H the magnetising field which would produce the same effect on the basalt bar as the current in question. On examination of two bars exposed thus at the observation tower on Monte Cimone in the Appenines, it was inferred that the currents were respectively 10,200 amperes and 5,530 amperes. It is held that the maximum lightning current would be double these figures, or even more since the basalt bars were not tested till several months after the lightning discharge and had in the meantime suffered vibration which would partially demagnetise them. [See further Abstracts, Nos. 295 and 1256 (1898).]
E. H. B.

1100. *Magnetic Effect of Electric Convection.* **V. Crémieu.** (Comptes Rendus, 132. pp. 327–330, Feb. 11, 1901.)—The author has repeated his former experiments [see Abstract No. 144 (1901)] in which a negative result was obtained, in order to meet objections arising out of the effect of the metallic screens between which his revolving disc moved. An ebonite disc, covered with gold-leaf along three sectors, moves, in its lower half, between two glass plates covered on their outer faces with tin-foil which is earthed, in its upper half between two ebonite discs, also covered externally with tin-foil. By means of a spring, the revolving disc is charged when passing between the lower plates, while, as it passes between the upper ones, the effect on an astatic needle is noted. To protect the latter from air currents, a dielectric screen is interposed, but it is then found impossible to suppress electrostatic effects. Finally an astatic needle fastened to a mica sheet is used, the whole being screened by some conductor. Again it is found that the turning disc produces no magnetic effect. In some cases a deviation is obtained; but as this is of the same order when the needle is removed from its mica support, it is due to an electrostatic effect on the latter. With an aluminium support the same result appears, but in this case it is reversible with the charge and the direction of rotation. In no case was a deviation of the needle noted when it was electrically well screened. After noting the numerous difficulties attending such experiments, the author again states his opinion that under the conditions of the experiments of Rowland, Himstedt, or those he has recently performed, electric convection produces no magnetic effect. R. S. W.

1101. *Action of Magnetic Field on the Discharge through a Gas.* **R. S. Willows.** (Phil. Mag. 1. pp. 250–260, Feb., 1901.)—While working with tubes in which the pressure varied from 0·1 mm. to 1 mm. it was noticed that under certain conditions the imposition of a transverse field caused a large increase in the current passing and a decrease in the potential-difference of the terminals, just the opposite of what generally occurs. As this did not appear to be due to any peculiarity of the tube, further experiments were made. The results of these are given in the present paper.

The effect is found to vary with the magnitude and position of the magnetic field, with the pressure of the gas, and with the relative sizes of the electrodes. Experiments were made with the tube in a variable field, and also in a uniform field, and the potential gradient was measured between the electrodes with the field on and off. Curves are given showing the variation of current due to the field as a function of the pressure, when the field is produced at the anode, at the kathode, and between the anode and kathode. These curves are duplicated for the cases when the disc electrode is kathode and when it is anode. Curves are also given showing the difference of potential between the terminals, and also the potential gradient throughout the tube both when in and out of the magnetic field. J. B. H.

1102. *Distribution of Current at the Kathode of a Vacuum Tube.* **A. Wehnelt.** (Phys. Zeitschr. 2. pp. 334–339, March 2, 1901.)—An investigation of the circumstances affecting the distribution of current across the surface of the kathode. A kathode completely filling the section of the tube is used, the inner part, a circular disc, being separated from the outer, a concentric ring: the current through either part or through both together is capable of measurement by a galvanometer. The sum of the separate currents is constant over the range of pressure used, and when the whole electrode is covered with the glow the currents through the separate parts are in the ratio of their areas. As the pressure is lowered the glow is confined more and more to the inner disc, and the current through the ring decreases, showing that the current flows through that part of the tube only which contains visible rays. If the discharge is oscillatory the current through the inner portion of the kathode may exceed the whole current. This arises from the fact that the ring acts as anode to the inner part of the whole electrode. With hollow electrodes similar results are obtained; at low pressures it is only the external part of the kathode which is useful in carrying the discharge. If the kathode is a circular disc cut in half along a diameter and the halves are made of different metals, then at the higher pressures most of the current goes from that metal which possesses the least kathode fall of potential, but as the gas is pumped out the currents through the two parts become equal, so that when the dark space is a few mm. long the relative magnitude of the fall for the two metals has no influence. By means of a magnetic field the current, as measured by the galvanometer, is shifted in the same direction as the visible glow. The cleanness of the surface of the kathode is found to exercise a considerable influence at higher pressures on the current distribution. If the surface of the electrode is increased by cutting grooves in it, the amount of current from it is found increased in the same ratio as the surface when the pressure is such that the whole area is covered with glow; at lower pressures this again has no effect. R. S. W.

1103. *Conductivity Produced by Ions.* **J. S. Townsend.** (Phil. Mag. 1. pp. 198–227, Feb., 1901.)—In a previous paper [see Abstract No. 2449 (1900)]

the author described some researches which led him to the conclusion that negatively charged ions, moving through a gas, produce other ions, although the force acting on them is very small compared with the force necessary to produce the ordinary vacuum tube or spark discharges. He now gives a more complete account of these experiments, and shows that at low pressures the current may be considered to pass through three stages as the e.m.f. is increased. In the first stage, the current increases with the e.m.f.; in the second stage, the current remains practically constant and shows only small variations for comparatively large changes in the force; in the third stage, the current rapidly increases with the e.m.f. It is the negative ions which produce the large increases of conductivity. The velocity acquired by a negative ion in travelling freely between two points differing in potential by 4 volts is 10 times as great as its velocity of agitation at ordinary temperatures. The number of collisions made by an ion in going through a centimetre of air at 1 mm. pressure is 21. At atmospheric pressure, each ion would produce some 10,000 other ions per centimetre, and the same number would be produced by a particle conveying "Becquerel rays." E. E. F.

1104. *Electric Waves of a Vibrating Ion.* **A. Righi.** (Archives Néerlandaises, 5. pp. 348–355, 1900.)—This paper begins with a general solution of the equations for an electric doublet, including, as a particular case, the solution originally given by Hertz. The mathematics is then developed for the case of a very small vibration at the source of the radiation, and is found to be in agreement with the result of putting the distance from the source great in Hertz's solution for his oscillator, viz., transverse waves, with the electric and magnetic vectors at right angles to each other in the wave front.

The view is then put forward that the vibrations of the particles in a luminous source may be regarded as the electric oscillations of a very small Hertzian oscillator. It is then shown that the charge on the ion may be supposed either positive or negative, and the bearing of this view on the Zeeman effect is discussed, especially the case where the ion executes a small circular motion. E. H. B.

1105. *Refraction of Electric Waves.* **G. Pierce.** (Phil. Mag. 1. pp. 179–198, Feb., 1901.)—By means of a modification of Boys' radio-micrometer [see Abstract No. 1848 (1900)], the author has measured the refractive indices of paraffin, ebonite, and various specimens of wood. The movable coil of the apparatus is traversed by thermoelectric currents produced by electric waves impinging upon a knot of fine platinum and platinum-nickel wire and heating up the junction. The measurements of refractive indices were made by observing the distance by which the interposition of a known thickness of the dielectric displaces the nodes of a stationary wave in air. The arrangement of apparatus for obtaining the stationary wave is essentially that of Lloyd's mirror for perpendicular incidence, the succession being radio-micrometer, oscillation, dielectric, and metallic mirror. The refractive indices of paraffin and ebonite for waves 4·4 cm. long were found to be 1·56 and 1·75 respectively. All the woods examined showed double refraction, black walnut, with indices 1·70 and 1·49 respectively, showing the largest divergence. The author shows from theoretical considerations that it is a case of true double refraction, and not an appearance due to differences of absorption. E. E. F.

1106. *Velocity of Propagation of Electric Waves.* **R. Blondlot** and **C. Gutton.** (International Physical Congress at Paris, Report, 2. pp. 268–

283, 1900.)—The Report contains brief accounts of the various methods of measurement which have given the following results (expressed in kilometres per second :—Blondlot (1891), 302,200 ; Blondlot (1893), 296,400 and 298,000 ; Trowbridge and Duane (1895), 300,300 ; C. A. Saunders (1897), 298,200 and 299,700 ; Maclean (1899), 299,110. D. E. J.

1107. *Hertzian Waves.* **A. Righi.** (International Physical Congress at Paris, Report, 2. pp. 301–324, 1900.)—This report deals with the practical applications of Hertzian waves and their identity with luminous waves. (1) *Apparatus for Producing and Studying Hertzian Waves.*—The intensity of the waves is increased by enclosing the spark-gap in an insulating medium (Sarasin and de la Rive). Righi finds that vaseline oil is the best liquid for this purpose. For experiments analogous to optical ones the waves have to be as short as possible. The most suitable oscillator consists of two spheres of copper separated by a layer of vaseline oil. In this way Righi obtained waves only 2·5 cm. long, and since then waves only a few millimetres in length have been obtained (Lebedef). A suitable resonator for use with this oscillator consists of a small piece of silvered glass, part of the metallic layer being removed so as to form a spark-gap a few thousandths of a millimetre broad. Some twenty other forms of indicator or resonator are described. (2) *Radio-conductors.*—Their mode of action is discussed, and also their application. (3) *Optics of Electric Waves.* — A *résumé* of experiments on interference, diffraction, absorption, transmission, reflexion, and refraction. (4) *Telegraphy by Hertzian Waves.*—A similar *résumé*, with a discussion of the action of the antennæ, maximum distance, secrecy, &c. D. E. J.

1108. *Wireless Telegraphy and Electrodynamics.* **M. Abraham.** (Phys. Zeitschr. 2. pp. 329–334, March 2, 1901.)—A mathematical paper dealing with electrical oscillations in a conductor similar to that used by Slaby in his experiments on the tuning of the transmitter and receiver. In previous papers the author has already investigated, on Maxwell's theory, the circumstances of the oscillations set up in a vertical wire for free and forced periods, and has shown the results agree with theory. In the present paper, assuming the free end of the wire to be a current node, the same results are approximated to by the use of much simpler analysis. A simple geometric construction is given, whereby the nodal points can be found. The energy lost by radiation during a complete period is found, as also that dissipated by heat. In the particular case of a wire 50 m. long and 0·5 mm. radius, it is found that the amplitude of the vibration sinks to $1/e$ of its initial value after 5 periods on account of losses by radiation, while 80 are required if losses due to dissipation of heat only are taken into account. With a receiver of the Slaby type, it is found theoretically that there is a much smaller logarithmic decrement, on account of the earth acting as a reflector for the horizontal wire. R. S. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1109. *Dielectric Constants of Pure Liquids.* **B. B. Turner.** (Zeitschr. Phys. Chem. 35. pp. 385–430, 1900.)—This paper describes measurements made by the author to determine with the greatest possible accuracy the dielectric coustants of certain pure liquids of a well-defined character, so that these liquids may serve as standards in other investigations. The method employed is Nernst's, in which the liquid is contained in a metal vessel,

forming one plate of the condenser, while a plate fixed to a stem passing through an insulating cover forms the other plate. Three different processes are applicable: (1) Comparison of the constants of two liquids by measurement of the capacity of the empty vessel, and of its capacity when filled with each liquid; (2) Absolute determination of the constant by measurement of the capacity of the vessel both when empty and filled, with the internal plate at different distances from the bottom; (3) Determination of the constant by measurement on the full and empty vessel, first with the plate attached to its stem, and then with the stem alone. The author discusses the distribution of the lines of force between the plate and stem and the vessel; the variations in this distribution, when the dielectric, or the height of the plate, is varied, introduce error into the methods mentioned. The error is reduced to a minimum in the third method, and it is this which the author employs in his measurements. He describes numerous improvements and modifications introduced into the measuring vessel, the adjustable condensers and resistances, as used by Nernst (Zeitschr. Phys. Chem. 14. p. 622, 1894), and gives details of a long series of tests carried out on the apparatus itself; from these he concludes that the method is capable of giving a value of the dielectric constant to within $1\frac{1}{2}$ to $2\frac{1}{2}$ per thousand. The following are the results obtained on various liquids:—

Benzol.—Pure benzol was twice purified by freezing out half its volume, and then was dried by sodium and distilled. Boiling-point, 80·33° — 80·36°. Dielectric constant, at 18° C., $2{\cdot}288 \pm 0{\cdot}0008$.

Ether.—Commercial ether was shaken up seventeen times with small amounts of water, then dried with calcium chloride, and distilled over sodium. Dielectric constant at 18° C., $4{\cdot}367 \pm 0{\cdot}0018$.

Aniline.—Aniline was purified in several different ways, the different samples showing some differences in their constants; the mean value was at 18° C., $7{\cdot}298 + 0{\cdot}014$.

Ethyl chloride gave a value at 18° C. of $10{\cdot}90 \pm 0{\cdot}01$.

o-Nitrotoluol was purified by twice freezing out, and dried by fractional distillation. Its dielectric constant at 18° C. is $27{\cdot}71 \pm 0{\cdot}05$.

Water was purified by distillation with phosphoric acid, and then with baryta water in a stream of air free from carbonic acid; the conductivity was 1×10^{-6} absolute units. The constant was $81{\cdot}07 \pm 0{\cdot}19$.

Nitro-benzol, fractionally distilled, and twice frozen out, gave a constant of $36{\cdot}45 \pm 0{\cdot}07$.

Metaxylol, fractionally distilled over sodium, gave a constant at 18° C. of $2{\cdot}376 \pm 0{\cdot}001$.

The author then gives a table of dielectric constants of different substances, not, however, purified and measured with the same care as those mentioned. As standard liquids he recommends benzol, *o*-nitrotoluol, and water. G. H. B.

1110. *Dielectric Strength.* **J. R. Bibbins.** (Elect. World and Engineer, 36. pp. 279–282, 1900.)—The author has collected the results of various experimenters concerning the relation between thickness of dielectric and the corresponding disruptive potential. So far as it is possible to generalise, he concludes that for an uniform field in air the sparking distance, for small thicknesses, is a quadratic function of the potential; for greater thicknesses the sparking distance is a simple linear function. Also for solids and liquids the spark length in an uniform field, for comparatively small thicknesses, is taken to be a linear function of the potential. Steinmetz, in his experiments

with air and liquids, separated the electrodes by pieces of glass or mica of measured thickness, these being perforated to allow the spark to pass through the material under test. Further experiment has proved that the introduction of the foreign substance into the field invalidates the results. If a metal disc is introduced between the electrodes, the disruptive potential may be much greater than without the disc. To explain this the author supposes a counter e.m.f. to exist at the various surfaces of separation of metal and air [see, however, O'Gorman's paper "Insulation on Cables," read Inst. of E.E., March 7, 1901]. The effect of increased frequency, when using alternating potentials, is to increase the convection currents indicated in air by a partial breaking down of the air stratum previously to the final disruption. Within the limits of frequencies 60–125, the effect of a change is not apparent; for high frequencies the convective discharges are very great, and the striking distance is largely increased. The corona, or luminous effect, observed when testing mica, should not be mistaken for disruptive discharge. The length of spark which then discharges over the surface is many times greater than can be accounted for by the corresponding calculated potential. R. A.

1111. *Temperature and the Dielectric Constant of Gases.* **K. Bädeker.** (Zeitschr. Phys. Chem. 36. pp. 305–335, Feb. 22, 1901.)—Let k be the dielectric constant, n_∞ the index of refraction for $\lambda = \infty$, $\kappa = k - 1$, $\nu = n - 1$; then from Maxwell's and Clausius and Mossotti's formulae, (1) that $k = n_\infty^2$ and (2) that $(k-1)/(k+2)$ is proportional to the density, we find $\kappa = 2\nu_\infty = \kappa_0 \frac{p}{76} \cdot \frac{1}{1+\alpha t}$. The work of Boltzmann (Pogg. Ann. 155, 407, 1875) of Klemenčić (Exner's Rep. 21, 571, 1885), of Lebedew (Wied. Ann. 44, 288, 1891), of Linde (Wied. Ann. 56, 546, 1893), all upon gases, is reviewed; as also that of Linde (same reference), Goodwin (Phys. Rev. 8, No. 40), Hasenoehrl (Communications Laborat. Camerlingh Onnes, No. 52, Leyden, 1899), and Dewar and Fleming (1899) on liquefied gases. Nernst's Wheatstone bridge method for gases (Zeitschr. Phys. Chem. 14, 622, 1894, and Philips in vol. 24 of the same, 1897), has been used in this research, with modifications described. The value $k = n_\infty^2$ is a minimum value of k. For normal gases $\kappa T = \kappa_0 T_0$. The research covered CS_2, SO_2, NH_3, HO_2, HCl, CH_4O, C_2H_6O, and $N_2O_4 \rightleftarrows 2NO_2$, in their relations to temperature. Where Maxwell's law fails to apply with changes of temperature, the Clausius-Mossotti formula is also invalid: and the two laws go hand in hand. Maxwell's law tends to be obeyed at high temperatures. A. D.

1112. *Capacity of Dielectrics in a Magnetic Field.* **E. C. Roberts.** (Phys. Rev. 12. pp. 50–52, Jan., 1901.)—Sheets of glass, hard, rubber and vulcanite (composition not given) were coated with tin-foil 5·3 cm. square, and were placed in a field of 1,500 lines per square cm., but no variation of capacity noted when the field was put on or off. A similar test was made with alternating pressure with similar negative results. A third more accurate method was used, capable of indicating a change of $\frac{1}{3\,3\,0\,0}$ of the whole capacity. The results of the experiments were entirely negative. M. O'G.

1113. *Variation of Dielectric Constants.* **M. v. Hoor.** (Elektrotechn. Zeitschr. 22. pp. 170–172, Feb. 21; 187–191, Feb. 28; and 213–215, March 7, 1901. Abstract of a paper read before the Hungarian Academy of Science, June 18, 1900.)—This paper is a description of experiments undertaken to investigate the variation of the constant of a dielectric under different

polarising forces. A condenser was constructed with dielectric consisting of two sheets of linen-paper, 0·045 mm. thick. The paper was dried at 110° C., then heated between copper sheets till just browned, and then soaked in petroleum ; the condenser when built up was soaked in petroleum in a vacuum of 80 mm. of mercury, for 150 hours ; during this process the hysteresis loss in the condenser fell to about one-fifth of its original value. Measurements were made with a ballistic galvanometer, and also with alternate currents ; full details are given in the paper of the methods employed and of the instruments used.

The maximum pressure between the terminals of the condenser was 954 volts, which, with the dielectric thickness of 0·009 cm., gave a value of the rate of fall of potential of 353 electrostatic c.g.s. units, a value very much higher than that reached by any other experimenter. At this pressure the polarisation energy per cubic cm. of dielectric was $0{\cdot}00128{\cdot}10^7$ erg, corresponding to the energy lost in cast-iron at an induction of about $B = 13000$. Tables and curves are given showing the results, and indicate considerable variation in the capacity with change in the pressure ; within the limits of the observations, the dielectric constant of the paper varied from 2·67 to 17·6.

In another series of experiments, curves of the rate of discharge of the condenser were taken by means of a damped mirror electrometer, the condenser being left to discharge through its own internal resistance. The resulting curves are shown between time and both $\log \frac{V_0}{V_t}$ and $\log \frac{Q_0}{Q_t}$, Q being the charge in the condenser.

These curves should be straight lines, were the dielectric properties constant ; they are, however, found to curve towards the axis of abscissæ, the charge curve bending over more than the pressure curve ; in other words, the pressure and the charge diminish with time more slowly than they would if the dielectric properties were constant. Comparison of the capacity curves as found by this method, and by the ballistic galvanometer, showed a very close agreement.

Finally the author describes experiments in which the pressure is varied by steps, and a hysteresis curve is given, which is exactly similar to the ordinary loop curve showing magnetic hysteresis. The loss of energy in hysteresis increases as the 1·7th power of the electrostatic induction.

G. H. B.

1114. *Function of Self-Induction in Wehnelt's Interrupter.* **T. Mizuno.** (Phil. Mag. 1. pp. 246–250, Feb., 1901.)—A series of experiments with a Wehnelt's interrupter in circuits of variable self-induction and capacity have led the author to conclude that in the action of an interrupter the function of self-induction is to break down the film of vapour formed at the electrode. The formation of this film stops the current, but, if the self-induction of the circuit is sufficiently great, the inductive current sparks through the vapour, breaking down the film and re-establishing the circuit. J. B. H.

1115. *Decrease of Electrical Resistance by use of Low Temperatures.* **R. Mewes.** (Elektrochem. Zeitschr. 7. pp. 212–224, Jan., 1901.)—A theoretical discussion of the Dewar-Fleming researches, dealing mostly with the question of the boiling-point of gases at low pressures. The author begins with the fundamental formulæ of thermometry, and by means of these develops others (especially a new expansion formula), which give him values for the boiling-points of oxygen and nitrogen at given low pressures

much larger than those found theoretically by Dewar from the formulas he used. The author points out wherein Dewar's formulæ are inaccurate, and shows that on applying his own formulæ to cases for which experimental data can be obtained, the calculated values approximate very closely to the observed values. The formula for the decrease of electrical resistance with decrease of temperature is not given, but is stated to be exactly similar to the author's expansion formula. W. C. H.

1116. *Frequency of Alternating Currents.* **R. Wachsmuth.** (Ann. d. Physik, 4. 2. pp. 323–326, Feb., 1901.)—This is a description of an exceedingly simple method of determining the frequency of an alternate current, being superior as regards simplicity even to that of Samojloff [see Abstract No. 117 (1901)].

It consists of a piece of watch-spring (see diagram) clamped in a vice, and provided with a small square piece of white paper stuck on by means of a

bit of wax. When this is illuminated by a source fed by an alternating current and set vibrating, it will appear to stand still when the frequency of the current equals its own frequency of oscillation. The latter can be calculated from the formula, $N = 7920$ thickness in mm. / (length in cm.)^2, but in practice a graduation could be easily marked on the spring itself. A small correction must be added for the paper in the case of light springs. The method is very convenient, and can be used for frequencies up to 150 per second, beyond which the springs become too stiff. E. E. F.

1117. *Volta Effect.* **Q. Majorana.** (Archives des Sciences, 11. pp. 266–281, March, 1901) [Compare Abstract No. 632 (1901).]—The present theories are practically two—contact effect and Lodge's tendency to chemical action. The latter would imply that two different metals, perfectly polished and deprived of all adherent air, have no potential difference, which has not been proved. Experiments as to differing potential-differences in different gases are inconclusive, since the condition of the surface is altered by the film of adherent gas. A method is described for measuring the Volta effect: a filament of quartz, silvered and charged at, say, 250 volts, is suspended between spheres of the two metals; the two spheres are connected by a wire put to earth, in which is a loop with two branches; in the one branch is a 100-ohm resistance coil, in the other is a similar coil. R_3, and an accumulator of great capacity, and, say, 2 volts. In front of

this loop the connecting wire is put to earth. Adjustment of the resistance coils enables the potential of the corresponding metallic sphere to be regulated from 0 to 2 volts by steps of 0·002 volt. The resistance coils are so used that $R_1 + R_2$ is always equal to 100 ohms : this is effected by taking out all the plugs from one box and always transferring to that box any plug taken from the other. With one box filled with its plugs adjust the position of the silvered quartz fibre until it always swings towards one of the metallic spheres or the other according to the sign of its electrification ; then adjust the plugs until the quartz fibre acts in the same way or does not move at all, whatever be the sign of its electrification. The two spheres are then at equal potentials, and the original difference of potential between the two metal spheres is $e = VR_1/(R_1 + R_2) = VR_1 / 100$, where V is the voltage of the accumulator. The effects of different conditions of polish are traced out, also that of low temperatures (liquid air). If a metal is kept for a very long time in a very dry gas, it becomes more negative, apparently as the result of drying merely : the similar effect of slight heat upon Au, Ag, Fe, Cu, may be due to the same cause. A method is described for ascertaining the mutual attraction between different metals by the aid of interference fringes of light passed between the two discs, of which one is made mobile on a balance ; mathematical discussion of the same, and establishment of a null method in which there are no fringes, and no displacement of the discs, in which the compensating potential is twice that which is to be measured, and in which also the distance between the discs can be computed if the sensibility of the balance is known. A. D.

1118. *Carpentier's Potentiometer.* **M. Aliamet.** (Electricien, 21. pp. 1–5, Jan. 5, 1901.)—The potentiometer circuit consists of 11 coils of 1,000 ohms and 11 of 10 ohms in series ; two coils of each series are shunted by 10 coils of 200 ohms and 10 of 2 ohms respectively. In series with a secondary cell are a coil of 10,000 ohms and two circular rheostats, going up to a total of 10,000 ohms by steps of 1 ohm. Another rheostat of a total resistance of 300,000 ohms, sub-divided in five portions, enables pressure up to 600 volts to be measured. The whole is enclosed in a box, only the handles of rheostats, sliding contacts, keys, &c., projecting ; the parts relative to calibration of the potentiometer against a Clark cell are kept distinct. G. H. B.

1119. *Meter for Three-phase Four-wire Systems.* **H. Aron.** (Elektrotechn. Zeitschr. 22. pp. 215–216, March 7, 1901. Paper read before the eighth meeting of the Verband Deutscher Elektrotechniker at Kiel.)—This paper describes two methods of adapting the Aron meter to read energy on three-phase circuits in which a neutral wire is used. If A, B, C, be the three-line currents, and D the neutral wire current, the equation connecting the line currents takes the form $A + B + C + D = 0$. The author deduces as alternative expressions for the power,

$$W = Ae_1 + Be_2 + Ce_3, \text{ or } = AE_2 - BE_1 - De_3,$$

where, e_1, e_2, e_3, are the voltages between each wire and the neutral, and E_1, E_2, E_3, are those between the three pairs of wires BC, CA, AB, respectively. The former expression can be written $W = Ae_1 + Be_2 - C(e_1 + e_2)$, and the meter is arranged to read this as follows : The two pendulum coils take the voltages e_1 and e_2 ; the former swings over two fixed coils, taking the currents A and C, and wound in opposite directions, so that the

pendulum reads e_1 (A — C). The second pendulum swings over the same coil taking C, and a third coil taking B, so that it reads e_2 (C — B); the difference between the rates of the two pendulums then gives the power. To economise space in the meter by placing the middle coil below the other two, the author also arranges the meter to read $W = AE_2 - BE_1 - 1/3D(E_1 - E_2)$, which is deduced from the second expression given above for the power. The pendulum coils then take E_2 and E_1 instead of e_1 and e_2, and the middle fixed coil, instead of taking C, takes D, and is placed below the others at a greater distance from the pendulums. The meter, arranged in either of these ways, is applicable to both star and mesh connections.

G. H. B.

1120. *Direct-Reading Wattmeters.* **H. Armagnat.** (Écl. Électr. 26. pp. 445–446, March 23, 1901.)—The author shows that with alternate current the error due to mutual induction is very small in those direct-reading instruments which have a moving coil. In a particular case, which he considers, he finds the error thus introduced to be less than 0·005 per cent., and in any case he considers it to be so small as to be practically negligible.

W. H. S.

1121. *Phasemeters.* **Armagnat.** (Soc. Int. Élect., Bull. 17. pp. 452–462, Dec., 1900.)—Phase-difference may be defined in different ways: (1) As the time or angle between the passage through zero of the two quantities; this is applicable only when the two curves are similar. (2) As $\cos^{-1} K$, where K is the ratio between the power and the amperes × volts. (3) As the angle ϕ, when $I \sin \phi$ and $I \cos \phi$ are the two components of, say, one current I respectively in phase and in quadrature with the second current.

Teichmuller's phasemeter, made by Siemens and Halske, consists of two rectangular coils fixed at right angles; in the centre of these coils hangs a moving system equivalent to the squirrel-cage of an induction motor; it is constructed of a glass cylinder covered with tin-foil, from which are cut strips parallel to the axis. Two currents out of phase by an angle ϕ, when passed through the two coils, exercise a movement on the squirrel-cage proportional to the sine of the angle. The instrument is adapted for measuring very small phase-differences, from some seconds to about 10 degrees. Arnò's phasemeter is described in Abstract 522 (1901). In Hartmann and Braun's phasemeter the moving system consists of two coils crossing each other at right angles and pivoted on a vertical axis passing through the points where the coils cross. One coil is in circuit with a high self-induction, the other has its resistance adjusted to take the same current at a given pressure and frequency. The system is pivoted within, and at right angles to the axis of, a coil taking the main current (the phasemeter being arranged to measure the phase-difference between the current and the pressure in any circuit). The two moving coils, connected in parallel across the circuit, produce a rotary field, and set themselves in such a position that this field is parallel to the field of the main coil at the moment when the current in it passes through its maximum.

The phasemeter made by the Allgemeine Company measures the phase-angle in accordance with the third definition given above. An aluminium disc controlled by a spiral spring turns between the poles of three electro-magnets; the central one takes the main current, and the two extremes are connected across the circuit; a high resistance in series with these ensures the current in them being in phase with the pressure. The torque on the disc

is then proportional to the current multiplied by the sine of the phase angle, the pressure being assumed constant. The author in conclusion gives reasons for doubting the accuracy of the indications given by these phasemeters. A bibliography of the subject is appended. G. H. B.

1122. *Induction Coils at the Paris Exhibition.* **H. Armagnat.** (Écl. Électr. 26. pp. 5–15, Jan. 5, 1901.)—Some very large induction coils were shown at the Paris Exhibition—two by Klingelfüss and Max Levy giving 1 m. sparks, and two by Ducretet and Radiguet giving 80 cm. sparks. The German coils have generally a straight cylindrical form with the primary circuit enclosed in an ebonite tube and movable relatively to the secondary; the primary is made considerably longer than the secondary. The Klingelfüss coil, however, has a complete iron circuit consisting of vertical U-shaped stampings, the legs of which take the coils, provided with pole-pieces with a narrow air-gap. The coils are wound by a special apparatus which lays the wires in the insulating medium in such a way that contiguous wires do not touch.

The condensers are generally separate from the coils. Rochefort and Ducretet alone employ liquid insulation; the former connects two secondary coils in parallel, and claims for this method a better spark than with one coil of wire of double the cross-section. With this coil Tirsot was able to signal nearly double the distance possible with an ordinary coil giving the same length of spark.

The circuit-breakers shown are of three types—dry circuit-breakers, those with liquid insulation, and electrolytic. The first are usual only with coils giving less than a 25-cm. spark, and cannot work regularly at a higher pressure than 20 volts. Macfarlane Moore's circuit-breaker has its armature and contact enclosed in a vacuum and worked by an exterior electromagnet; the spark in vacuo is very much reduced. Villard showed two mercury contact-breakers actuated by the movement of a wire, forming part of the circuit, in the gap of a permanent magnet; when current passes in the wire its motion in the gap breaks circuit. A larger type with tuning-fork, making 40 to 45 vibrations per second, is adapted for use with alternate currents; for this the tuning-fork is actuated by a transformed current, while the untransformed current passes through the contact to the coil; by this means the time of contact can be adjusted so that the circuit is broken at the moment of maximum current, while it is made when the current is zero, and the coil therefore receives current impulses in one direction only. A common type of circuit-breaker is one in which a vertical wire is moved in and out of the mercury by an electromotor; this type is not suitable for high frequencies. Gaiffe, by attaching a circuit-breaker at each end of the motor, reaches a frequency of 100 periods. The Allgemeine Elektrizitäts Gesellschaft showed a circuit-breaker in which a turbine driven by an electromotor draws up mercury from a well to a hollow horizontal disc, from the periphery of which it issues in a jet, and falls again into the well; the jet in turning impinges on the teeth of an iron ring, with which it makes and breaks contact. In Max Levy's circuit-breaker, of a similar type, the dented ring is rotated as well as the turbine, and the mercury jet is stationary; in this the time of contact can be adjusted. Ducretet's circuit-breaker consists of a metal disc and a star mounted on the shaft of an electromotor and each dipping in a separate mercury cup. In Hirschmann's type contact is made by one copper strip sliding over another fixed strip, each being amalgamated to ensure good contact with little friction. Siemens and Halske showed a Wehnelt circuit-

breaker with water-cooling to enable it to be worked continuously at a pressure above 50 volts. On the other hand, Carpentier showed a model with felt lagging to allow working at low voltages. G. H. B.

1123. *Three Forms of Thomson Bridge for Measuring Low Resistances.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 22. pp. 157–158, Feb. 14, 1901.)—In this paper the normal type of Thomson bridge with Uppenborn's shunt is first described, after which three constructional forms are explained. The first is a bridge for instructional use, in which the standard wire and graduated scale are 30 cm. long and the knife-edge contacts at both ends thereof are adjustable; the distance between the fixed knife-edge contacts for the bar to be tested is also 30 cm. In the second bridge described, which is of the Uppenborn type (see Centralblatt für Electrotechn. 1886, p. 289), the standard wire and graduated scale are 1 metre long. Finally, a workshop form is described, in which the distance between the knife-edges for the bar to be tested is adjustable by securing one pair of knife-edges at different points along bars, which are themselves capable of being adjusted by hand levers relatively to a fixed pair of knife-edges. The movable contact for the slide wire is mounted on a carriage provided with wheels running on a prismatic rail. Diagrams of the connections and photographs of the apparatus are given in the original paper. C. K. F.

1124. *Alternate-current Measurement by Electrometers.* **G. L. Addenbrooke.** (Electrician, 45. pp. 901–903, 1900. Abstract of paper read at the International Electricity Congress, Paris, 1900.)—The author has adapted his electrometer [Abstract No. 864 (1900)] to the measurement of alternating pressure, current, and power. Three instruments are employed: a voltmeter, reading up to about 100 volts; an ammeter, consisting of an electrometer reading up to about 2 volts, and arranged to measure the drop of volts across a known resistance; and a wattmeter, in which the two pairs of quadrants are connected across a resistance through which the current passes, while the needle is connected to the other side of the circuit, so that the potential difference of the circuit is established between the needle and quadrants. By adjusting the distance between the quadrants, the instruments can be made direct-reading. The wattmeter reads proportionately within one-half of 1 per cent. over a range of 200 m. (scale at 2 metres) and within 1 per cent. over 300 m. The ammeter electrometer, on account of its greater sensitiveness, does not give so exactly proportionate a scale. The three instruments are arranged as follows: To a bus-bar, forming one terminal of the source of power, are connected one pair of quadrants of the wattmeter and the quadrants of the ammeter and voltmeter, a standard cell, a battery in series with an adjustable resistance, a potentiometer resistance of 100,000 ohms, and the current-measuring resistance. The voltmeter needle is connected to the centre of a four-way switch, of which one point forms the second terminal of the source of power, a second and third are connected to the other end and to the moving contact of the potentiometer resistance, and the fourth point short-circuits the instrument. The needle of the wattmeter is connected to the centre of an exactly similar switch. The needle of the ammeter and the second pair of quadrants of the wattmeter are connected to two other four-way switches, with contacts as follows: One connected to the current measuring resistance, one to the Clark cell, one to the moving contact of the potentiometer resistance, and one short-circuiting the instrument. Between each pair of contacts on the four

switches is an intermediate passing contact, short-circuiting the instrument through a resistance of 20,000 ohms; this is to avoid the sudden deflections which may occur on the break of circuit in passing from one contact to another. With these arrangements the instruments can all be calibrated in terms of the Clark cell and the current measuring resistance; the methods of calibration are fully described in the paper. G. H. B.

1125. *Condenser of Adjustable Capacity.* **G. Ercolini.** (N. Cimento, 12. pp. 279–280, 1900.)—Brigg's adjustable condenser [see Abstract No. 2223 (1900)] made of flexible mica plates subjected to varying pressures, gives a wide range of capacities, but is open to the objection that the variation of capacity with pressure follows an unknown law, and is not always a certainty. The author has, therefore, improved upon it by substituting glass plates for the flexible plates. The glass plates are mounted one above the other on metallic rails laid into an ebonite scaffolding. The scaffolding can be sheared like a parallel ruler, so that the glass plates can be made to approach each other to any extent desired. Sheets of tin-foil stuck on both surfaces serve as the metal plates. The capacity varies with the cosine of the angle of inclination of the guiding rod. The condenser can, of course, be used as an air-condenser, or immersed in a liquid. E. E. F.

1126. *Alternating Current Wave Recorder.* **F. A. Laws.** (West. Electn. 28. p. 128, Feb. 23, 1901. Also Amer. Acad., Proc. 36. pp. 321–324, Jan., 1901.) —This arrangement of apparatus is a modification of the "contact method," and gives a continuous record which is traced photographically. It is a device for obtaining the average wave and is unsuitable for recording transient phenomena. Two rigidly connected contact wheels of ebonite are driven by means of a synchronous motor. By means of worm gearing the brushes are made to move uniformly round the contact wheels, the ratio of reduction being 7,200 to 1. A spot of light from a Sullivan universal galvanometer is focussed on a camera and the photographic plate is moved vertically by means of a fine wire wound on a drum. The time taken for recording a wave when the frequency is 120 is 1½ minutes. Examples are given of records of pressure and current waves in various interesting cases. A. R.

ALTERNATING CURRENTS AND MAGNETISM.

1127. *Direct Tracing of Alternating Curves.* **A. Blondel.** (International Physical Congress at Paris, Report, 3. pp. 264–295, 1900.)—The report begins with an historical survey of the gradual development of the direct methods of recording the shapes of the waves of alternating currents and e.m.f.'s. The author describes three forms of oscillographs: (1) The bifilar, (2) the vibrating strip, and (3) the vibrating plate oscillograph. The principle of all these instruments is founded on the general equation for dead beat galvanometers, namely—

$$K\frac{d^2\theta}{dt^2} + A\frac{d\theta}{dt} + T.\theta = GI \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where K is the moment of inertia of the moving parts, A the damping coefficient, T the couple of torsion, G the galvanometer constant, and I the current. In order that I may be proportional to θ, the first two terms of this equation must be negligible. The author concludes that a good instrument must fulfil the following conditions:—

(1) The free period of oscillation of the instrument must be less than the

fiftieth part of the period of the required current curve. (2) The damping must be adjusted until the instrument just becomes dead beat. (3) The self-inductance of the instrument must be so small that its effect on the shape of the wave is negligible. (4) Hysteresis and eddy currents must be negligible. (5) It must be very sensitive, and hence the moving parts must be minute.

The author describes the modifications he has introduced into the latest form of his bifilar oscillograph. These improvements were for the most part suggested by an exhaustive theoretical consideration of the problem. For example, he considers the two bands rigidly connected at the middle by a mirror as forming a solid, and applies Saint-Venant's method to find the period of the torsional vibrations. He gives the solution in full, and points out that it shows (1) that $\frac{T}{c}$ should be large, where T is the tension of either band, and σ is the area of its cross-section; (2) that the bands should be square or round; and (3) that $\frac{\rho}{E}$ should be made as small as possible by choosing a suitable metal where ρ is the specific gravity of the metal and E its coefficient of elasticity. The author now uses round or square aluminium rods of very small section for suspending the mirror. He has reduced the period of vibration to between the ten thousandth and fifteen thousandth part of a second, and the sensitivity of the instrument is such that a current of 1 ampere produces a deflection of 80 centimetres when the scale is 1 metre from the mirror. He adopts Ewing's conical poles in order to get a strong field, and has an air-gap of only about 0·6 to 1 millimetre.

In the latest form of his vibrating strip oscillograph he uses an iron strip about 0·2 to 0·3 millimetre broad and a few hundredths of a millimetre thick, stretched vertically in the magnetic field, and carrying a little mirror at its centre. This band is enclosed in an oil case containing a lens. Each element of the band behaves like a little magnet, and the deviation increases from the ends to the middle of the band, where it is a maximum, the total deviation being proportional to the current. A free period of the fifty thousandth part of a second can be obtained by this arrangement. For industrial purposes the author states that these oscillographs are the best, and they can be made double or triple so that pictures of two or three curves can be thrown on the screen at once. Oscillographs play the same part in alternating current work that Watt's indicator does for the steam engine, and their precision is very much greater. They have been successfully employed in practical industry in France by the firms of Farcot and Bréguet.

Another method of getting the shape of alternating current waves is by the rheograph of Abraham. In this instrument, which is a kind of galvanometer, the free vibrations of the moving parts are less rapid than the alternations of the current to be examined. The inertia and damping, however, are compensated by means of electromagnetic induction. A current which is defined by the equation—

$$i = k\frac{d^2I}{dt^2} + a\frac{dI}{dt} + tI,$$

where I is the current to be studied, is passed through the galvanometer; then by equation (1) we see that I will be exactly proportional to θ if we make—

$$\frac{k}{K} = \frac{a}{A} = \frac{t}{T}$$

He attains this result by making use of four coils so as to get mutual induction effects between them.

The author states that this method is the most ingenious of the direct methods, and neither damping nor inertia limit its application. The only drawback is that the coils introduce a certain amount of inductance in the circuit, and this may alter the shape of the wave we have to measure. It is said that it can be used to record the shape of waves having a period of only the ten thousandth part of a second—a result quite out of the question with an oscillograph.

What the author calls the "oscilloradiograph" of Braun makes use of the deviation of the rays produced in a kathode tube excited by the alternating current whose wave form is desired. At present this method is most imperfect because the apparatus required is very complicated and the curve traced lacks precision. A certain amount of inductance is also brought into the current circuit, and this may alter the current wave. This method may be useful for tracing wave shapes at very high frequency, as the rays seem to be deflected instantaneously without any apparent inertia effect. A. R.

1128. *Effect of Aluminium Valves on Current Curves.* **G. Mayrhofer.** (Elektrotechn. Zeitschr. 21. pp. 913–915, and 926–929, 1900.)—To study the influence of an aluminium cell upon the curves of an alternating current, a Braun kathode-ray tube was used, and the displacements of the beam were

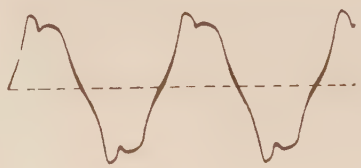


FIG. 1.

FIG. 2.

FIG. 3.

drawn out and photographed by means of a revolving mirror. The effect depends upon the current density, the e.m.f., and the electrolyte used in the aluminium cell. Potassium bichromate is more effective as a rectifier than alum, especially at low voltages, but at higher voltages it shows a great tendency to produce luminosity of the electrodes. It is more profitable to employ a single effective cell than to join several less effective ones in series. Some examples of curves are given in the accompanying diagrams, where Fig. 1 represents an unmodified curve, Fig. 2 a curve produced by using a very small aluminium electrode with an e.m.f. of 25 volts, and a current density of 0·3 amperes per sq. cm., and Fig. 3 by using a somewhat stronger

current. The author describes a beautiful acoustic experiment, in which the pitch of a vibrating iron armature is lowered by an octave on introducing an aluminium valve. E. E. F.

1129. *Direct Method of Harmonically Analysing Alternate Currents.* **T. des Coudres.** (Elektrotechn. Zeitschr. 21. pp. 752–755, and pp. 770–772, 1900.)—The principle of this method will be found explained in Abstract No. 1035 (1899). The present paper contains an account of some experimental investigations carried out in order to test the practical value of the method. The author finds that the accuracy of the method exceeds that of methods in which the actual shape of the current-wave is traced. The sine-inductor used consisted of two fixed solenoids placed end to end, which acted as field magnets, giving rise to a uniform field. In this field was rotated a small circular coil, 2 cm. in diameter and 1 cm. wide, wound with 500 turns of silk-covered wire 0·3 mm. in diameter. By means of variable toothed gearing the coil could be driven from the alternator shaft at any required multiple of the speed of synchronism. An ordinary torsion wattmeter, constructed by Ganz & Co., was used for measuring the mean couple due to the interaction of the current under test and the current furnished by the sine-inductor. A. H.

1130. *Trend of the Horizontal Component of the Earth's Magnetic Field in France.* **E. Mathias.** (Comptes Rendus, 132. pp. 320–322, Feb. 11, 1901.)—This is a continuation of the paper referred to in Abstract No. 146 (1901). The author has continued his calculations, and now considers that the formula given in the previous Abstract ought more correctly to be—

$$\Delta H = -1{\cdot}16\,(\Delta \text{ long.}) - 7{\cdot}32\,(\Delta \text{ lat.}).$$

He finds that this expression gives the value of H at undisturbed stations for the epoch January 1, 1896, not only throughout France, but also for many stations in the neighbouring countries. W. W.

1131. *Testing Magnet Steel.* **I. Klemenčič.** (Ann. d. Physik, 4. 2. pp. 316–322, Feb., 1901.)—The usual method is somewhat rough and ready; it consists in magnetising, exposing to repeated shocks, and finding the amount of decrease in the magnetic moment. This may serve in cases where the magnet is intended to undergo vibration; but where the desideratum is a constant moment in a state of rest the principal cause of changes in the moment is variations in the temperature, and testing the steel for this involves extending the tests over a long time. The kind of steel which is best for the one purpose is by no means necessarily so for the other. Experimental data are given. In general, at rest magnets with smaller coercitive forces give better results, so that soft iron makes the most constant permanent magnet, its residual magnetism being astonishingly constant so long as no shock or vibration occurs. A. D.

1132. *Magnetic Mirror Images.* **H. Jaeger.** (Ann. d. Physik, 4. 2. pp. 345–366, Feb., 1901.)—The investigation bore first upon the screening action of iron plates in a magnetic field. The magnetic field examined was that of a straight current. Magnetometry was not possible, and the method adopted was that of rotating a coreless coil in a constant field, checked by using the coil at rest in the field of a varying current. The percentage of screening action increases as the primary current diminishes. The field of a

straight current lying upon a sufficiently large and soft iron plate is doubled through the presence of the iron, as if there had been a similar current similarly situated within the surface of the iron, a kind of magnetic virtual image. The amount of strengthening of the field may fall short of this doubling, according to the breadth and the hardness of the iron and the strength of the current. Comparative tests were made with a real current in the place of the virtual current; and solenoids were now employed instead of straight wires. Optical analogies were pursued with success, in respect of virtual images produced by inclined mirrors and kaleidoscopic effects. A. D.

1133. *Magnetic Balance.* **G. Guglielmo.** (Archives Néerlandaises, 5. pp. 175–180, 1900.)—The author at the commencement of 1900 described an areometer devised by him, consisting of an asymmetric mass immersed in the liquid, with one end (provided with a suitable knife-edge) resting against a horizontal glass plane, either above or below, according to whether the areometer be heavier or lighter than the liquid.

By attaching a bar magnet the areometer becomes a magnetic balance of extreme sensibility, and its movements may be observed by a mirror and scale. The author describes the methods he has employed to determine the horizontal and vertical magnetic components, but he has not compared his determinations with measurements made by a magnetometer. Variations of temperature have considerable influence on the measurements. G. H. B.

1134. *Design of Electromagnetic Mechanisms.* **W. W. Soubbotine.** (Russian "Electrotechnical Courier," 7. pp. 586–590, Dec., 1900.)—Referring to an article of S. P. Thompson's in the New York Electrical Review, the author points out that the expression there given for the pull exerted by an electromagnet, viz.—

$$f = i\frac{d\psi}{dx},$$

where i is the current, ψ the magnetic flux, and x the displacement, is not correct, and represents *double* the actual pull. He then proceeds to develop a general theory applicable to all electromagnetic mechanisms as follows: Let $p = -f$ be the value of the external force which is necessary to keep a given electromagnetic system in equilibrium (the system may be subject to any given kinematical constraints; p in that case denoting the force required to balance that component of the total force due to the interaction of the various portions of the system, which acts in the direction of the displacement); let L = inductance of the system. Then the total work done on the system by the external force p when a small displacement dx is given to the system in the direction of p is—

$$dw_1 = pdx = -fdx,$$

part of which work will be converted into electrical energy, given by the equation—

$$dw_2 = eidt = -\frac{d(\mathrm{L}i)}{dt}idt.$$

$$= -i^2\frac{\partial \mathrm{L}}{\partial x}\cdot\frac{dx}{dt}dt = -i^2\frac{\partial \mathrm{L}}{\partial x}\cdot dx,$$

where e is the e.m.f. induced in the circuit by the displacement; while the remainder, given by—

$$dw_3 = \frac{\partial w_3}{\partial x}dx,$$

will go towards increasing the potential energy w_3 of the system. By the conservation of energy, we have—

$$dw_1 = dw_2 + dw_3,$$

i.e.—

$$-f dx = -i^2 \frac{\partial L}{\partial x} dx + \frac{\partial w_3}{\partial x} dx,$$

whence—

$$f = i^2 \frac{\partial L}{\partial x} - \frac{\partial w_3}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

It remains to calculate the potential energy w_3 of the system. The e.m.f. induced in the system when x is maintained constant and i undergoes an infinitesimal change is given by—

$$e' = -\left(\frac{d(Li)}{dt}\right)_{x = \text{const.}} = -\left(i\frac{\partial L}{\partial i} \cdot \frac{di}{dt} + L\frac{di}{dt}\right) = -\left(i\frac{\partial L}{\partial i} + L\right)\frac{di}{dt}$$

and the work done in increasing the current is—

$$e' i dt = -(i^2 \frac{\partial L}{\partial i} + iL) di.$$

Hence the total potential energy corresponding to an increase of current from zero to the value i is given by—

$$w_3 = -\int_i^0 (i^2 \frac{\partial L}{\partial i} + iL) di = \int_0^i (i^2 \frac{\partial L}{\partial i} + iL) di = \int_0^i (i^2 \frac{\partial L}{\partial i} di + \int_0^i iL di \ldots\ldots (2)$$

Integrating the first of these two integrals by parts, we get—

$$\int_0^i i^2 \frac{\partial L}{\partial i} di = \int_0^i i^2 dL = Li^2 - 2\int_0^i iL di.$$

Substituting this in equation (2), we get—

$$w_3 = Li^2 - \int_0^i iL di,$$

so that—

$$\frac{\partial w_3}{\partial x} = i^2 \frac{\partial L}{\partial x} - \frac{\partial}{\partial x}\int_0^i iL di = i^2 \frac{\partial L}{\partial x} - \int_0^i i\left(\frac{\partial L}{\partial x}\right) di,$$

and hence, using (1)—

$$f = \int_0^i i\left(\frac{\partial L}{\partial x}\right) di \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The author then proceeds to apply this general formula to various special cases. A. H.

REFERENCES.

1135. *Electric Waves.* **J. A. Fleming.** (Soc. Arts., Journ. 49. pp. 69–84, Dec. 28, 1900; 86–95, Jan. 4; 97–112, Jan. 11; and pp. 113–131, Jan. 18, 1901.)—A course of four Cantor Lectures entitled respectively, Electric Oscillations, Electric Resonance, the Electromagnetic Medium, and Electric Waves. The subject is here presented in a semi-popular manner, but with such fulness of illustration and references to the authorities concerned as to make the articles a very valuable *résumé* of the ground covered. E. H. B.

1136. *Hysteresis.* **E. Warburg.** (International Physical Congress at Paris, Report, 2. pp. 509–531, 1900.)—The author deals with (1) The history of the subject, including hysteresis of field, of deformation, and of temperature. (2) Pseudo-hysteresis of dielectrics. (3) Analogy of mechanical strain. (4) Various factors affecting hysteresis. (5) Ewing's theory. (6) Change in properties of iron at 800°, and Osmond's theory. (7) Hysteresis of pure iron. The paper is followed by an appendix by van't Hoff. [See Abstract No. 1165 (1901).] P. E. S.

1137. *Theory of Electric Induction.* **G. Bakker.** (Archives Néerlandaises, 5. pp. 312–321, 1900.)—A mathematical paper which claims to give a more direct and complete proof of certain electromagnetic equations than that due to Maxwell. The equations are a cyclical set of three, of which only one is here given, viz. :—

$$P = H_z \frac{dy}{dt} - H_y \frac{dz}{dt} - \frac{\partial F}{\partial t} - \frac{d\psi}{dx},$$

where F, G, and H are the components of a vector whose integral along a circuit multiplied by the intensity of the current, gives the potential energy with respect to the electromagnetic field ; and H_x, H_y, and H_z are the components of a vector, of which the integral over the area of the surface of the circuit equals that just named ; finally P, Q, and R are the components of a vector whose line integral along the circuit gives the induced e.m.f. E. H. B.

1138. *Influence of Ferromagnetic Crystals.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 3. pp. 331–344, 1900.)—This paper treats of the subject mathematically and cannot be well abstracted. The observations of P. Weiss on magnetite, published in a thesis presented to the Faculty of Science of Paris in 1896, are especially dealt with. T. H. P.

1139. *Contact Electricity.* **C. Christiansen.** (International Physical Congress at Paris, Report, 2. pp. 390–402, 1900.)—A clear and comprehensive summary of the results obtained and theories advanced by experimenters in the subject, from the time of Volta up to the date of the Congress. J. E.-M.

1140. *Mode of Propagation of Energy and Electric Tension in the Electromagnetic Field.* **J. H. Poynting.** (International Physical Congress at Paris, Report, 2. pp. 284–300, 1900.)—A discussion of the nature of the electromagnetic field existing around conductors traversed by a current. The ideas of Faraday and Maxwell are extended so as to explain the behaviour of the energy and electric tension when the system is not in equilibrium. The medium surrounding the conductor is regarded as the chief seat of the action. Among the subjects discussed are the localisation and transference of energy, electromagnetic waves, discharge of condenser, circuit containing a battery, and the movement of tubes of force and electric tension. D. E. J.

1141. *Currents of High Tension and Great Frequency.* **Molloy.** (Elect. Rev. 48. pp. 37–38 ; Discussion, p. 38, Jan. 4, 1901.)—Abstract of a paper read before the Dublin Section of the I.E.E.

1142. *Striæ in Geissler Tubes.* **E. Riecke.** (Ann. d. Physik, 4. 2. pp. 388–401, Feb., 1901.)—A paper similar to that referred to in Abstract No. 852 (1901), but of greater length. J. B. H.

1143. *Recent Researches on Atmospheric Electricity.* **F. Exner.** (International Physical Congress at Paris, Report, 3. pp. 415–437, 1900.)—A summary of recent investigations on the daily and annual variations of atmospheric electricity, the variation of the field at different heights, and other problems in this subject ; followed by a discussion of the different theories propounded, and mention of the points which still require to be cleared up by experiment. W. C. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1144. *Intimate Structure of Crystals. Cubic Crystals with Octahedral Cleavage.* **W. J. Sollas.** (Roy. Soc., Proc. 67. pp. 493–495, Feb. 5, 1901.)—*Diamond.*—Carbon, m.w., 12 ; sp. gr., 3·51 ; m.v., 3·42. Each atom is in the closest contact with twelve others in planes normal to the trigonal axes of the cube which they are supposed to form. The volume of the atoms is found by dividing the atomic volume by 1·35 ; it is 2·54 ; the diameter of the atom is 1·693, and its gross volume 4·851. The atoms lie closest in planes parallel to the faces of an octahedron, hence the cleavage. Diamond is tetrahedral : the hemihedry may be accounted for by the grouping of the atoms, or by a tetrahedral nature in the carbon atom itself, the constituent tetrahedra in both cases being all similarly orientated. The author refers to Barlow (Sci. Proc., R. Dubl. Soc., viii. 533, 1897). He next gives a comparison with graphite. A specimen obtained in the manufacture of carborundum was introduced into a diffusion column of methylene iodide and benzene ; and floated at a level of sp. gr. 2·286, as given by small glass indicators. The value deduced from this is m.v. 5·25 ; Petersen (Zeit. Phys. Chem. viii. 601 1891) obtained 5·3. The crystalline form is now considered to be monoclinic. If a number of tetrahedral groups of atoms be placed each with a trigonal axis vertical, the atoms at the base forming a single sheet in close contact, and a similar sheet be superposed with vertical axes continuous with the lower ones, the resulting symmetry will be oblique and hemimorphic. The volume of the packed spheres in the case of the diamond will be to that in graphite as 2 to 3, corresponding to the ratio between the molecular volumes, 3·42 to 5·25. This structure in graphite would be a loose one, and would approach closely to the symmetry of the rhombohedral system, accounting for the softness and for the crystallographic form. [See further Abstract No. 144 (1899).] S. R.

1145. *Nernst's Formulæ for the E.M.F.'s of Concentration-Cells.* **H. Jahn.** (Zeitschr. Phys. Chem. 36. pp. 453–460, March 12, 1901.)—The author replies to Arrhenius' objection [see Abstract No. 908 (1901)], namely, that Nernst's formulæ are inexact, owing to the fact that ions passing from one solution to another of different concentration do not necessarily remain as ions except in very dilute solutions. Jahn points out that Nernst's formulæ are obtained by calculating the net changes of free energy occurring in the process under consideration. As the state of any layer of solution will always be indefinitely near the state of equilbrium between ions and non-ionised salt, there are no changes of free energy attending the combinations or dissociations of ions caused by electrolytic conduction, and therefore it would be quite erroneous to correct Nernst's formulæ for the reason given by Arrhenius. It is further pointed out that Nernst's formula can be deduced from that of Arrhenius, if the law of mass-action for the ionic equilibrium be assumed, and the statement is made that the three equations (1) Nernst's formula ; (2) Arrhenius's formula ; (3) Ostwald's "dilution" law, are so related that any one can be deduced from the other two. Hence the ionic concentrations calculated by Jahn, since they satisfy (1) and (3) must satisfy (2), so that Arrhenius's criticism recoils on himself. F. G. D.

1146. *Mixtures of Hydrochloric Acid and Methyl Ether.* **J. P. Kuenen.** (Archives Néerlandaises, 5. pp. 306–311, 1900.)—Mixtures of these two substances are interesting, since it follows from Friedel's work on the subject that they exhibit a maximum of B.Pt., and therefore a minimum of vapour-pressure. The object of the present investigation was to trace this minimum up to the critical region, and to obtain a complete pressure temperature diagram. This programme could not, however, be completely carried out, since even at temperatures below 100° C. irreversible chemical action occurs, with the production chiefly of methyl chloride and water. Nevertheless the following facts could be ascertained :—

(1) The mixtures have a minimum vapour-pressure in accordance with what could be derived from Friedel's experiments. This minimum exists up to the critical condition.

(2) Addition of hydrochloric acid raises the critical point of methyl ether.

A pressure-temperature diagram is given showing the results obtained. The author points out that the production of a liquid boiling much higher than methyl ether does not prove the formation of a double compound, since a high value for the mutual attraction constant, a_{12}, in van der Waals' equation would sufficiently account for the result. Even the abnormal vapour density is not a perfectly certain criterion. F. G. D.

1147. *Equilibrium between Ester, Water, Acid, and Alcohol.* **H. Euler.** (Zeitschr. Phys. Chem. 36. pp. 405–412, March 12, 1901. From the Öfversigt af K. Svenska Vetenskaps-Akadem. Förhandl., 1900, No. 9.)—The hydrolysis-equilibrium in acid solution is investigated in the case of the methyl, ethyl, and propyl esters of acetic, propionic, formic, and chloracetic acids, and it is found that the degree of hydrolysis of an ester *increases* with the strength of the acid, which is contrary to what would be expected if an ester be regarded as an *ionisable* salt in which the alcohol plays the part of the basic constituent. If, however, it be supposed that the alcohol can act as the acidic constituent, *i.e.*, if, for example, ethyl acetate be regarded as a salt-like compound which ionises in *both* the following ways,

$$\overset{+}{C}H_3CO \,:\, \overset{-}{O}C_2H_5, \quad \overset{+}{C}_2H_5 \,:\, \overset{-}{C}H_3COO,$$

then it can be shown by considering the various possible equilibria that the *increase* of hydrolysis with *increase* in the dissociation-constant of the generator acid is possible. In conclusion the author points out that the view that the hydrolysis of an ester occurs chiefly in the former of the two ways indicated above, is in complete agreement with the conclusions deduced by van't Hoff (Zeit. Phys. Chem. 13. p. 493, 1893), from a study of the velocities of saponification, and of hydrolysis in acid solution of various esters.

F. G. D.

1148. *Solubility of Metallic Precipitates Determined Electrolytically.* **C. Immerwahr.** (Zeitschr. Elektrochem. 7. pp. 477–483, Feb. 28, 1901.)—From the potentials of metallic electrodes immersed in saturated solutions of their salts, especially those of very slight solubility, the concentration of the metallic ions and the solubilities of such salts may be calculated. The method affords the best means of determining the solubility of the more insoluble salts, which are of importance in qualitative chemical analysis. Mercury, copper, lead, zinc, and cadmium compounds have been experimented with, and the results obtained are given in tabular form. N. L.

1149. *Change of Free Energy in the Formation of Some Difficultly Soluble Salts.* **A. Klein.** (Zeitschr. Phys. Chem. 36. pp. 361–371, Feb. 22, 1901.)—The author has measured the e.m.f.'s at different temperatures, and hence determined the temperature-coefficients of e.m.f. for various cells constructed according to the scheme :

$$M, [MX'_n], \underset{100}{\overset{n}{}} - KX', n - KNO_3, \underset{100}{\overset{n}{}} - KX'', [MX''_n], M$$

where M may be Pb, Cu', or Ag, and X may be Cl, Br, I, or SO_4. The square brackets indicate the *solid* (difficultly-soluble) "depolariser." In this way are obtained the decrease of free energy, and the variation of the total energy (heat of reaction) for the following reactions, supposed to take place in complexes which are $\underset{100}{\overset{n}{}}$ with respect to the "soluble" salts :—

1.	$[PbCl_2]$ + 2KBr	$\rightleftharpoons$	$[PbBr_2]$	+ 2KCl
2.	$[PbBr_2]$ + 2KI	$\rightleftharpoons$	$[PbI_2]$	+ 2KBr
3.	$[PbCl_2]$ + 2KI	$\rightleftharpoons$	$[PbI_2]$	+ 2KCl
4.	$[PbCl_2]$ + K_2SO_4	$\rightleftharpoons$	$[PbSO_4]$	+ 2KCl
5.	$[PbBr_2]$ + K_2SO_4	$\rightleftharpoons$	$[PbSO_4]$	+ 2KBr
6.	$[PBI_2]$ + K_2SO_4	$\rightleftharpoons$	$[PbSO_4]$	+ 2KI
7.	[CuBr] + KI	$\rightleftharpoons$	[CuI]	+ KBr
8.	[AgCl] + KBr	$\rightleftharpoons$	[AgBr]	+ KCl
9.	[AgBr] + KI	$\rightleftharpoons$	[AgI]	+ KBr
10.	[AgCl] + KI	$\rightleftharpoons$	[AgI]	+ KCl

Substances not in square brackets remain *in solution*. The arrow indicates the direction in which the double decomposition takes place in the temperature-region investigated (0–40° C.). A very interesting case is afforded by reaction No. 6. Here the reaction proceeds from left to right if the temperature be greater than 8° C., in the opposite direction if the temperature be below that value.

The reactions 4, 5, and 6 (from left to right, *i.e.*, at temps. $> 8°$ C.) are found to be *endothermic*, and are therefore specially interesting as examples of endothermic reactions occurring at "ordinary" temperatures. The reaction 6 is exothermic or endothermic according as the temperature is below or above 8° C. It must not be forgotten that these reactions occur in presence of solutions of definite specified concentrations. For experimental details the original must be consulted. The usual methods of measuring e.m.f. were employed. The solutions were all normal with respect to KNO_3 in order to reduce the p.d.'s at the liquid junctions to a minimum. F. G. D.

1150. *Polarisation of Voltameters.* **G. di Ciommo.** (N. Cimento, 12. pp. 258–279, 1900.)—A new method is used for measuring the polarisation of a silver voltameter immediately after the passage of a current impulse. The results show a distinct polarisation of silver electrodes immersed in nitrate of silver. The laws obeyed by the polarisation in question are the following : The e.m.f. of polarisation is only a function of the quantity of polarising electricity. It equals the sum of the polarisations of the two electrodes, and these polarisations are equal if the electrodes have equal areas. The e.m.f. of polarisation is inversely proportional to the area of the electrodes, for the same quantity and temperature. As regards the dependence of the e.m.f. of polarisation, E_0 upon the quantity of electricity, E_0 increases at first with Q, then the increase

becomes more gradual, and at a certain value of Q a diminution sets in, rapid at first, and then more and more gradual. Heating diminishes E_0. The film which covers silver in air, whatever its nature, increases the value of E_0.

E. E. F.

1151. *Liquefaction of a Mixture of Two Gases.* **P. Duhem.** (Journ. Phys. Chem. 5. pp. 91–112, Feb., 1901.)—If a mixture of two gases at constant temperature T be subjected to increasing pressure, the system consists of two phases, liquid and vapour, while the pressure varies between two values, for one of which the mixture is all liquid, and for the other of which it is all gas, and provided that T does not correspond to a Gibbs-Konowalow point. The author studies the variations with pressure of the concentrations of these phases. He proves that, if through a point (T, π) within the limiting line of a mixture of mean concentration X there pass a single dew line (for mean concentration *s*) and a single boiling line (for mean concentration S), then for pressure π and temperature T the mixture of mean concentration X will consist of a liquid phase of concentration S, and a vapour phase of concentration *s*. Unless the system possesses a Gibbs-Konowalow line, two distinct boiling or dew lines cannot pass through the same point. If the system possesses one or more Gibbs-Konowalow lines, there may pass through a point (T, π) several dew and several boiling lines. To distinguish which of these are the *useful* dew and boiling lines, the author proves many properties of these sets of lines, and demonstrates the possibility of studying the changes of composition of the liquid and its vapour during isothermal compression by drawing a sufficiently fine network of limiting lines. The cases in which retrograde condensation and vaporisation respectively occur are particularly investigated.

W. E. T.

1152. *Potential Change in Oxidation Chains.* **K. Schaum.** (Zeitschr. Elektrochem. 7. pp. 483–484, Feb. 28, and 523–524, 1901.)—In the course of the author's investigations of concentration cells containing an oxidising agent and the product of its reduction [see Abstract No. 1227 (1899)] sulphite-sulphate cells were also examined as being an example of chains, in which the oxidising and reducing agents formed non-isomeric ions. Their behaviour was found to be greatly influenced by the addition of a few drops of benzyl alcohol, the reaction $\overline{\overline{SO_3}} + \overline{\overline{O}} \rightleftarrows \overline{\overline{SO_4}} + 2(-)$ being thereby accelerated, and the cell rendered reversible and analogous to the ferrocyanide-ferricyanide system previously described.

N. L.

1153. *Method of Comparing the Affinity Values of Acids.* **H. J. H. Fenton** and **H. O. Jones.** (Chem. Soc., Proc. 17. pp. 24–25; Discussion, p. 26, Feb. 15, 1901.)—When the hydrazone of oxalacetic acid is heated with water it undergoes decomposition to the extent of 83–90 per cent., the exact number depending on the purity, the products being the hydrazone of pyruvic acid and carbon dioxide. In the presence of sufficiently concentrated acids, however, no carbon dioxide is given off, but water is lost and the pyrazolone carboxylic acid of Wislicenus formed. Parallel experiments with different acids show that the volumes of carbon dioxide obtained are in the inverse order of the affinity-values of the acids. In explanation of this behaviour, the authors suggest that the undissociated molecule of the hydrazone tends only to lose water giving the pyrazolone derivative, but that the negative ion $CO_2H.CN_2HPh.CH_2CO_2$ is unstable, and tends to lose carbon dioxide. According to this hypothesis, any circumstance tending to prevent

ionisation should favour the production of the pyrazolone derivative, while the presence of a sufficient concentration of hydrogen ions should cause the change to take place in this direction more or less completely. A series of experiments has hence been carried out to determine the influence on the reaction of various salts, non-electrolytes, acids in presence of the corresponding salts, and solvents other than water. The results, which are, on the whole, well in harmony with the ionisation hypothesis, lead to the following conclusions: (1) The influence of salts, bases and non-electrolytes is *nil*, the results being practically identical with that given by pure water. (2) The effect of a salt in presence of its acid is to greatly diminish the influence of the acid. (3) Solvents having different ionising powers give very different results, the amount of carbon dioxide evolved being greatest in the case of water, less for amyl alcohol, and least for toluene and nitrobenzene. T. H. P.

1154. *Relation between the Specific Volumes of Coexisting Fluid Phases.* **J. D. van der Waals.** (Archives Néerlandaises, 5. pp. 407–416, 1900.)—The assumption that the potential energy of a normal substance is completely determined by the work done against surface tension leads to the relation $(dv_1/dt)/\beta_1 + (dv_2/dt)/\beta_2 = 0$, where v_1 and v_2 are the specific volumes of the co-existing fluid phases at the temperature t, and β_1, β_2 are their compressibilities. Calculations in regard to ether show that this relation posseses a high degree of approximation. If it is exact, the molecular pressure is strictly of the form $av^{-2}f(t)$. R. E. B.

1155. *Conductivity of Solid Electrolytes at High Temperatures.* **W. Nernst** and **H. Reynolds.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 3. pp. 328–330, 1900).—The substance, in the form of thin rods, was heated in a platinum oven, consisting of a thin tube of magnesia with 10 per cent. steatite, wound round with platinum wire, the winding being plastered over with magnesia. The temperature was determined by a thermo-couple. Contact was made at four points of the rod, and three readings taken on a Kohlrausch bridge so as to eliminate the contact resistances. Pure oxides have exceedingly high resistances. The specific conductivity of MgO at 1,500° C. is 0·000085; of LaO_2 at 1,200°, 0·00081; Y_2O_3 at 1,320°, 0·082, while at 1,040° it insulates completely. Mixtures, however, conduct comparatively well, and curves are given showing the increase of conductivity for various mixtures. Mixtures of Thoria, Zirconia and Ceria conduct badly, as also do mixtures of Yttria and Erbia. Mixtures between these two groups, however, conduct relatively well. [See further Abstract No. 1910 (1899).] G. H. B.

1156. *Electrolytic Alkaline Periodates.* **E. Müller.** (Zeitschr. Elektrochem. 7. pp. 509–516, March 21, 1901.)—Perchlorates can be prepared by electrolysing neutral chlorate solutions without a diaphragm in the cold, but under similar conditions an iodate is reduced quantitatively to the iodide at the kathode, whilst at the anode a partial reoxidation of the iodide to the iodate occurs. The reduction at the kathode can be very much diminished by adding a small proportion of potassium chromate to the neutral solution. In a divided cell periodates can be produced in considerable quantity, the essential conditions for a good yield (up to about 26 per cent.) being a low temperature, low current-density, and at least 4 per cent. of caustic alkali in the solution. T. M. L.

1157. *Electrolysis of Phenol in Presence of Hydrogen Chloride, Bromide, and Iodide.* **H. Zehrlant.** (Zeitschr. Elektrochem. 7. pp. 501–505, March 14.

1901.)—When phenol is electrolysed in presence of normal hydrogen chloride it is not chlorinated, but oxidation takes place and the phenol thus acts as a depolariser and reduces the anode-potential from 1·3 to 0·862 volts. A similar effect is produced in presence of normal sulphuric acid. In presence of normal hydrogen iodide the phenol is unchanged, and the anode potential is the same (0·52 volts) as when no phenol is present. In presence of normal hydrogen bromide the phenol is oxidised and not brominated, but when the strength of the acid is increased fourfold a partial bromination results. The anode-potentials were measured against a normal hydrogen electrode throughout. T. M. L.

1158. *Electrolysis of Hydroxyacids.* **J. Hamonet.** (Comptes Rendus, 132. pp. 259–261, Feb. 11, 1901.)—The electrolysis of potassium β-amyloxy-propionate results in the formation of 1:4 diamyloxybutane. Of chemical interest only. N. L.

1159. *Aluminium as an Electrode.* **A. Bartorelli.** (N. Cimento, 1. pp. 112–133, Feb., 1901. Paper read at the annual meeting of the Italian Society of Physics, Sept., 1900.)—It has been long known that when an aluminium electrode is the anode in a voltameter the current passing is much weaker than when it is the kathode. History and references are given. There is some superficial change in the aluminium anode. The nature of this change is a subject of controversy. The resistance is very high, and the polarisation may attain very high values (17 volts, Streintz); but it is necessary to know these more definitely in terms of the current passing. A method is described for ascertaining the polarisation and the internal resistance concurrently during the passage of the current. If I be the current, E the p.d. at terminals, ϵ the counter e.m.f., and ρ the internal resistance of the voltameter, we have, where the aluminium electrode is the anode, and with current densities above 0·0025 and up to 0·1 ampere per sq. cm.,

$$E = I/(a + bI), \text{ where } a \text{ and } b \text{ are constants.}$$

The polarisation ϵ first neutralises the proper e.m.f. of the platinum-aluminium couple, and when it becomes $= 0$, the value of E/I is 155 ohms. The polarisation seems always to pass from negative to positive values at a current density of 0·0025 ampere per sq. cm. In long series of experiments while b is fairly constant, a seems to vary in such a way that $a/s = 0{\cdot}0002$, where s is the area of the electrodes. We also find (the electrode being still the anode) that for current densities from 0·004 to 0·1 ampere per sq. cm.,

$$4\,a\,\rho = (1 + a\rho - b\epsilon)^2,$$
$$\epsilon = bE^2 = bI^2/(a+bI)^2,$$
$$\rho = a/(a+bI)^2 = (1-bE)^2/a.$$

The resistance of the voltameter diminishes, while the polarisation increases, as the current passing increases, the increase in the polarisation becoming progressively smaller. The polarisation is proportional to the square of the p.d. between the voltameter terminals, and it tends to become equal to it ($\epsilon = E$, and $b = 0{\cdot}04$), and therefore tends towards a maximum, when $E = 25$ volts. The resistance similarly tends towards a minimum. In voltameters differing in section or in distance between the plates, the polarisation is the same when the current density is the same. The resistances of different voltameters are independent of the distances between the electrodes at given

current densities, and are inversely proportional to their electrode surface. With the aluminium acting as kathode the polarisation gradually increases with the current density up to a maximum, after reaching which it is constant. The resistance at the same time gradually falls to a limit sensibly equal to the resistance of the electrolyte alone. The maximum polarisation when the aluminium is the kathode is notably less than that when it is the anode. For equal values of p.d. at the voltameter terminals the resistance is always less when the aluminium is the kathode than when it is the anode; and as the p.d. rises from very small values the ratio between the resistances in the two cases, at first very small, rises and approaches unity when the p.d. is about 25 volts. The summation of the effects of a gradually falling resistance and a counter e.m.f. gradually rising from negative values makes the current apparently undergo a considerable increase at a particular limiting value of the p.d.; but in reality there is no abrupt change. A. D.

1160. *Electrometallurgy of Copper.* **G. Codara.** (Elettricità, Milan, 20. pp. 20–21, Jan. 12; 39–41, Jan. 19; 56–57, Jan. 26; and pp. 67–70, Feb. 2, 1901).—The electrolytic separation of copper has one of two objects in view, either the separation of copper from its ores or its purification. Various processes for the latter purpose are now in commercial use, and are gradually taking the place of non-electrolytic methods. The electrolytic separation of copper from its ores, however, has not yet succeeded industrially. Four processes have been tried—Body's, Siemens and Halske's, Höpfner's, and Marchese's. The first process employs a horizontal carbon anode on which the ore lies, the kathodes being copper plates enclosed in felt; the electrolyte, of ferric sulphate and salt, is kept in circulation. In Siemens and Halske's process the ore is first roasted to reduce the copper to subsulphide; it is then treated with a solution of ferric sulphate with free sulphuric acid, whereby copper sulphate is formed, which is then electrolysed. This process has been worked on a large scale at Martinikenfel, at Pena de Herro and in the Tyrol without success. In Höpfner's process the carbon anode and copper kathode are separated by a diaphragm, and separate currents of a solution of protochloride of copper in brine are passed over each. The solution passing the kathode deposits its copper, that passing the anode retains it in the form of bichloride; the two solutions combined are passed over the ore, which changes the bichloride again into protochloride, with liberation of sulphur. The process was tried in the Saxony Erzgebirge, at Giessen and at Wiedenau without success. At Safenburg it gave good results with Rio Tinto 3·37 per cent. ore, the production being 54 kilos of copper per h.p. in twenty-four hours. In Marchese's process the low e.m.f. required to decompose the sulphide was taken advantage of by having anodes of copper sulphide cast in the form of plates. The electrolyte of copper sulphate was obtained by treating rich ore with dilute sulphuric acid. The process was tried at Casarza and at Stolberg without success, the low e.m.f. expected not being realised in practice. The last article is a description of the commercial process of purifying copper by electrolysis. The author treats of the various impurities which may occur in the copper, their behaviour during electrolysis, their effect in impoverishing the electrolyte, and their effect on the back e.m.f. He then describes the various processes and vats of Siemens and Halske, Borchers and Goslar, Stahlmann, Hayden, Smith, Randolf, and Thofehrn. Copper electrolysis has its greatest development in the United States, where there are twelve plants with a total capacity of 400 tons daily. G. H. B.

1161. *Mercury Cell for Electrolytic Soda and Chlorine.* **E. Franke.** (Amer. Electn. 13. p. 104, March, 1901.)—The author describes a new form of mercury cell in which the mercury is used as kathode in the form of a falling stream, with carbon or platinum anodes of larger superficial areas. The advantages claimed for this form of cell are :—(1) Low e.m.f. consequent upon rapid removal of the mercury amalgam from the cell. (2) High current efficiency. (3) Diminution of weight of mercury required to obtain a given yield of soda. (4) Increased yield per unit of plant, due to the use of cells containing a large number of alternate vertical anodes, and falling mercury kathodes. As regards the weight of mercury required, the author gives figures showing that using a warm concentrated salt solution with carbon anodes 3 cm. apart, a flow of 2 grammes of mercury per second sufficed for a current of 0·7 ampere when the e.m.f. was 4 volts. By substituting platinum for carbon, the current with the same e.m.f. was increased to 1·2 amperes. In an experiment upon a larger scale, 500 grammes mercury per second were required to carry a current of 160 amperes with an e.m.f. of 4 volts and carbon anodes. This weight was reduced to 100–150 grammes per second, for the same current, when platinum was used as anode material. Owing to the rapid passage of mercury through the cell the amalgam obtained from it is not rich in sodium. Cells of glazed stoneware, 31½ inches square, with alternate anodes and kathodes as described, can be used for currents of 3,000 amperes at 4 volts. An electrical current efficiency of 98 per cent. has been recorded with this form of cell. J. B. C. K.

1162. *Electrolytic Phosphorus.* (Elect. World and Engineer, 37. pp. 360–361, March 2, 1901.)—This article contains a brief illustrated description of the method of producing phosphorus, worked out by Dr. Machalske in his laboratory at Long Island City, New York. Ordinary phosphate rock is used as raw material. No details are given of any preliminary grinding or mixing, so presumably the rock is used in its natural state.

The furnace is constructed of red-brick and fire-clay. The sides are lined with calcined magnesia. The hearth is formed of a block of carbon, and forms one electrode, while a movable rod of carbon, 8 feet long and 4 inches in diameter, functions as the other. The actual furnace cavity is only 12 inches by 18 inches. Each furnace is provided with a hopper for charging the raw material, and with flues for carrying away the vapours of the phosphorus produced. These are condensed under water. The other product of the electrolysis is a slag which flows away as produced from outlets in the side of the furnace. No detailed figures for the yield of this furnace are given, but it is stated that using electric energy costing 3 cents per e.h.p.-hour, yellow phosphorus can be produced at a cost of only 7 cents per lb.

A company called the Anglo-American Chemical Company has been formed to exploit this process upon an industrial scale. J. B. C. K.

1163. *Electrolytic Hypochlorites.* **A. Brochet.** (Elektrochem. Zeitschr. 7. pp. 263–265, March, 1901.)—The author in this article describes the Hermite, Corbin, Kellner, and Haas and Oettel forms of cell for hypochlorite production, and gives figures for the yields of the cells.

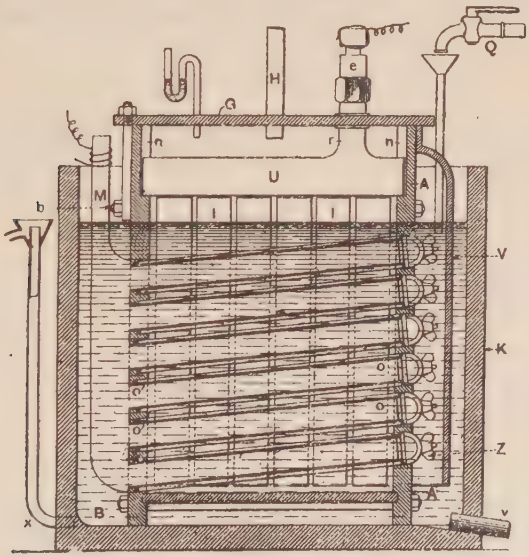
These are slightly different from those given in other articles upon this subject [see Abstract Nos. 1902 (1900) and 537 (1901)]. For the Hermite cell 1,000–1,200 amperes at 5–6 volts are stated to yield 40 kg. active chlorine per 24 hours. The yield for the Corbin cell is given as 50 kg. active chlorine per

24 hours with a current of 150 amperes at 120 volts. The Kellner type of cell with secondary electrodes of glass covered with platinum-foil (the glass and foil being perforated, and the foil kept in position by platinum wires passing through the perforations), yields 5·5 kg. active chlorine in 3 hours with a current of 114 amperes at 112 volts. For the Haas and Oettel cell, the figures given are 6 kg. active chlorine in 10 hours with a current of 40 amperes at 110 volts.

It is not stated whether these figures are based upon the author's own experiments or whether they are based upon trials made by the inventors of the various types of cell. J. B. C. K.

1164. *Outhenin-Chalandre Electrolytic Alkali Process.* **J. B. C. Kershaw.** (Electrician, 46. pp. 853–854, March 29, 1901.)—This process for the production of alkalies and chlorine compounds by the electrolysis of solutions of sodium or potassium chloride, is a diaphragm one, and is in actual operation at Chevres, near Geneva, and at Moutiers in France, while works are being built for the same process in Italy and Spain.

The figure is a sectional elevation of the cell, which consists of the outer



and inner vessels, K and A. The inner vessel is filled with rows of porous-diaphragm tubes o o, in communication at one end with the chamber K, as shown. Each tube contains an iron kathode, which runs the whole length of its interior, while the anodes are round rods of carbon fixed into the lead head-piece U, from the surface of which the chlorine is carried away by the outlet pipe H.

The inner chamber A, is nearly filled with a concentrated solution of sodium chloride, and the outer with dilute sodium hydrate. The electrical connections are then made.

The chlorine gas evolved is employed for the manufacture of bleaching powder, and for the manufacture of pure chemicals for laboratory and medical purposes, while liquefied chlorine is also one of the products of the

works. The sodium liberated at the kathode surfaces decomposes the water, with formation of caustic soda, which, owing to its high specific gravity, travels down the tubes, and collects on the bottom of the cell, and when required is run off by the outlet pipe V.

The hydrogen liberated at the kathodes is collected and burnt in a special form of burner in an atmosphere of chlorine, the resultant hydrochloric acid being fed into the anode chamber for the decomposition of hypochlorites. The excess of hydrochloric acid is split up by the electrolysis into its component parts, with production of chlorine at the anode and hydrogen at the kathode.

The advantages claimed for this class of cells are :—Complete separation of the electrolyte in the anodic and kathodic compartments, with consequent prevention of hypochlorite and chlorate formation. Collection and utilisation of the hydrogen evolved.

The author is rather doubtful about the advantages of this cell, and until figures have been published, showing the yield under actual working conditions, comparison of its efficiency with the Castner and Hargreaves-Bird cells is impossible.

Photographs of the power station of the Geneva Municipality and the Electrolytic Alkali Works at Chevres, Switzerland, are also given. O. J. S.

REFERENCES.

1165. *Transformation of Iron Compounds.* **J. H. van't Hoff.** (International Physical Congress at Paris, Report, 2. pp. 532–535, 1900.)—This is an appendix to the report on hysteresis referred to in Abstract No. 1136 (1901). The author gives an account of the transformations which take place in iron at 850° and of the carbon compounds which appear to play a part in these changes. P. E. S.

1166. *Electrochemical Industries in* 1900. **J. B. C. Kershaw.** (Electrician, 46. pp. 388–391, Jan. 4 ; and pp. 428–429, Jan. 11, 1901.)—A general review of the present conditions of commercial electrolysis.

1167. *Deposition of Metals from Mixed Electrolytes.* **R. A. Lehfeldt.** (Electro-Chemist, 1. pp. 12–13, Jan., 1901.)—A concise account of modern views on the deposition of metals from mixed electrolytes. The practical bearing of Nernst's logarithmic formula for the e.m.f. of a metal immersed in a solution of one of its salts is explained, and illustrated by the experiments of Ogg and Sand. N. L.

1168. *Ionisation of Solutions.* **S. Arrhenius.** (International Physical Congress at Paris, Report, 2. pp. 365–389, 1900.)—A brief but admirable historical and critical *résumé* of the subject written in a simple though precise style. J. E.-M.

1169. *Theory of the Voltaic Cell.* **L. Poincaré.** (International Physical Congress at Paris, Report, 2. pp. 403–421, 1900.)—This article gives a brief sketch of the gradual development of the theory of the voltaic cell. It is divided into three sections. Section I. deals with the application of the laws of thermodynamics without subsidiary hypotheses, and gives an account of the theoretical development of this portion of the subject in the hands of Helmholtz and Gibbs, together with a brief account of the experimental researches which have verified the theory. Section II. deals with the *mechanism* whereby the potential-differences are produced, and consists chiefly in a description of the Nernst-van't Hoff-Arrhenius theory. Section III. deals with the *seat* of the electromotive force. The author appears here to favour the view that in the case of an ordinary cell with different metals as electrodes, the p.d.'s at the metallic junctions play no inconsiderable part, and refers to the researches of Kelvin and Pellat in support of this view. F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

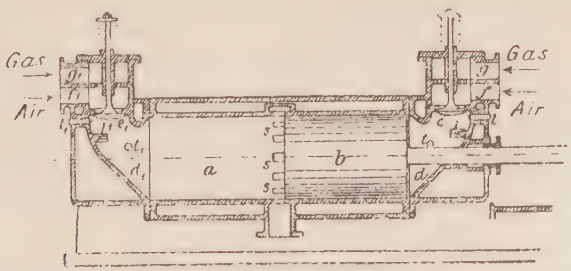
1170. *Steam Turbine.* (Engineering, 70. pp. 830–831, 1900. Electrician, 46. pp. 425–428, Jan. 11, 1901.)—Accounts of a test of a 1,000-kw. set of steam turbine and alternator, constructed by C. A. Parsons & Co., of Newcastle, for the Electricity Supply Works at Elberfeld. The following table gives a summary of the results:—

Load.	Output.	Steam per hr.	Steam per kw.-hr.
Overload	1,190·1 kw.	10,485 kg.	19·43 lbs.
Normal load	994·8	9,092	20·15
Three-quarter load	745·3	7,542	22·31
Half load	498·7	5,695	25·20
Quarter load	246·5	3,774	33·76
No load	0	1,183	—

These results are not directly comparable with one another, as they were not all made under the same conditions of steam-pressure and superheating. The steam pressure was about 10 atmospheres (absolute) and mean superheat 26° F. H. R. C.

GAS AND OIL ENGINES.

1171. *Koerting 350-h.p. Gas Engine.* (Engineer, 91. pp. 23–24, Jan. 4, 1901.)—This two-cycle engine has one motor cylinder double-acting, like a steam engine, with a piston-rod and cross-head working through guides, and a crank. There is an admission lift valve, shown in the figure, at each end of the cylinder, driven from a cam shaft. The discharge of the burnt products



is through ports, s, and through the annular passage around the middle of the cylinder uncovered by the piston. The length of the double-acting piston is equal to the stroke, less the width of the exhaust ports. The gas and air enter the admission valves by separate pipes from two double-acting pumps, both driven from an auxiliary crank 110° in advance of the motor crank. There is a projection in the cylinder below each admission valve, to prevent the heavy incoming gases streaming down to the exhaust ports, leaving the burnt products in the upper part of the cylinder. A scavenger charge of air is first

admitted between the products of combustion and the fresh explosive charge. To ensure prompt ignition there are two electric ignition ports at both ends of the cylinder at two different places in the compression space.

The usual cycle is carried out in two strokes instead of four. At light loads the gas-pump piston-valves, acted on by the governor, hold open the connection with the gas-pipe longer, and thus as the speed increases more gas is returned to the pipe and less passes to the cylinder.

The stuffing-box has metallic packing, and is carefully water-cooled. The cooling water for the piston and piston-rod is conveyed through tubes of the sliding telescopic type, moving to and fro with the cross-head.

The first 350-h.p. engine of this kind was tested by Meyer, at the works of Messrs. Koerting. The diameter of the motor cylinder was 21·6 inches, stroke 37·7 inches; diameter of the air-pump 24·4 inches, of the gas-pump 19·6 inches, and stroke of both pumps 27·5 inches.

The engine was driven by power-gas from a Koerting producer, and the work was absorbed by an electric brake which was not very reliable. The consumption was taken in a large gas-meter, and the (lower) heating value of the gas frequently measured by means of a Junkers calorimeter. The results in a trial run of an hour at full load were :—

Mean (metric) power indicated in the motor cylinder	544	h.p.
„ „ „ pumps	63	„
„ „ effective indicated	481	„
„ „ on the brake	341·5	„
Mechanical efficiency	71	per cent.
Mean number of revolutions per minute	101	
Heating value of the gas (lower) B.Th.U. per cubic foot	129	

Consumption of Gas per hour in cubic feet.

Consumption of gas per total i.h.p. (including pumps)	51	
„ „ „ (excluding pumps)	58	
„ „ brake h.p.	81·5	

Thermal Efficiency of Engine.

Thermal efficiency per gross indicated h.p.	37·9	per cent.
„ „ effective „	33·5	„
„ „ brake h.p.	23·8	„

The compression pressure was 12·5 atmospheres (absolute), and the maximum explosion pressure 27·5 atmospheres. The gas consumption could not be quite satisfactorily verified. Assuming it was 4 or 5 per cent. above the figures given, the heat utilisation was still very good, viz., 24 per cent. of the heat supplied to the engine converted into useful work on the brake. It remains to be seen how the double-acting piston and stuffing-box wear.

W. R.

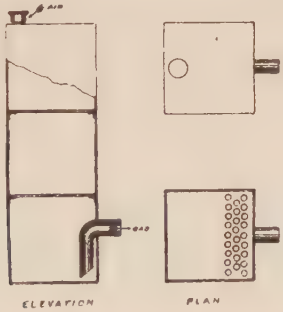
1172. *Test of Gas Engines and Producers.* (Lightning, 18. pp. 594–595, 1900.)—The plant at Harmsworth's Works, Gravesend, consists of three Stockport T-size gas engines, each giving 80 b.h.p. at 200 r.p.m., and driving by belts Mavor and Coulson dynamos, at 560 r.p.m.; also two Dowson producers of 80 h.p. each. The two generators and two engines were worked alternately for a total period of 36 hours. The anthracite used was from the Gwaun-Cal-Gurwen colliery, costing £1 8s. 3d. on the wharf. The mean load was 41 kw., or 75 per cent. of the normal. The power was measured in

electrical h.p. ; the efficiency of the dynamos was taken as 90 per cent., and of the belt 95 per cent. The ignition tubes were supplied with town gas, the consumption being 15–20 cubic feet per engine per hour. The following figures give the results of the tests (by Handcock and Dykes), the consumption of fuel including stand-by losses in one generator for 36 hours.

Anthracite per kw.-hour	1·86 lbs.
,, b.h.p ,, ...	1·18 ,,
Coke per kw.-hour	0·305 ,,
,, b.h.p. ,, ...	0·193 ,,
Total fuel per kw.-hour	2·16 ,,
,, b.h.p. ,, ...	1·37 ,,

G. H. B.

1173. *New Gas Producer.* **J. A. Purves.** (Inst. Engin. and Shipbuilders, Trans. 44. pp. 18–23, Nov.; Discussion pp. 4–18, Dec., 1900.)—"Air-gas" consists of a mixture of air and vapour of petroleum or liquid hydrocarbon, such as gasoline, petroleum spirit, or pentane. The proportion of vapour which can be taken up varies with the temperature of air and the volatility of the petroleum. Air-carburetters may be divided into three classes :—(1) Air is *forced under pressure* through or over liquid petroleum ;



(2) on account of the danger of using large quantities of liquid petroleum, an absorbent is employed to take up the hydrocarbon, and air is forced over or through the absorbent ; (3) air flows by gravity through the "aero-gas fountain" described in this paper.

In 1895, Naum Notkin, of Moscow, took advantage of the property that carburetted air is heavier than ordinary air. His automatic carburetter, called an "aero-gas fountain," consists of a tin vessel, shown in the Figure, with an orifice at the top and a bent "draw-off" pipe at the bottom, filled with a porous material (wood pulp) which is impregnated with one of the lighter hydrocarbons. Two perforated shelves give a long travel to, and distribute, the air. Air enters at the top, and taking up hydrocarbon vapour becomes heavier and gravitates through the mass of absorbent, taking up more and more of the vapour, until it issues from the lower orifice, and may be used for lighting, heating, and power purposes. The gaseous mixture becomes heavier and cooler by the rapid volatilisation of petroleum.

Argand burners with steatite centres and very wide gasways give with this "air-gas" a light of high illuminating power. No attention is necessary beyond the refilling of the carburetter when it becomes empty. Illustrations are given in the paper showing the application of this carburetter to table and

street lamps, ships' lights ; also to stoves and heaters. When the carburetter is exhausted of petrol, the tin box can be lifted out and a fresh one put in its place.

The yield of the aero-gas from a gallon of petroleum will give in an ordinary Argand burner from 700 to 1,000 c.p.-hours, depending upon the quality of the petroleum used. With petroleum at 1s. per gallon the cost of light is equivalent to that of 14-c.p. gas at 3s. 4d. per 1,000 cubic feet, giving 2·8 c.p.-hours per cubic foot. The gas can be used more economically in the Wenham and Siemens regenerative burners than in the Argand, and still greater efficiency is obtained with incandescent mantles. The aero-gas fountain can be used for gas engines, motor cars, and for launches.

Discussion.—**T. B. Murray** pointed out the only novel feature was that the apparatus worked by gravity, and hence did not require a fan to blow or force air through the gasoline. This property was of little or no value for motor cars or gas engines, since the suction caused by the forward stroke of the piston gave ample flow of air for carburation. Somewhat similar carburetters had been tried and abandoned for several reasons, such as the difficulty of obtaining a proper explosive mixture due to the varying temperature and humidity of the atmosphere ; consequently in a car the mixing valves required continual adjusting by an expert to get good results. Again, the lighter hydrocarbons were evaporated first, leaving behind a residue, in some cases heavy and difficult of volatilisation with cold, damp air. A *spray* carburetter was more suitable, since it depended on mechanical action, and in practice a good explosive mixture could be obtained under all conditions—winter and summer, wet or dry. He asked how the petrol was fed into the carburetter, and what was the total weight of the latter containing the four gallons of petrol required for a 100 miles' run. **F. J. Rowan** said the convenience of the Notkin apparatus was due to the absence of all machinery. There were no waste products as in the case of acetylene and similar gas generators. Gasoline vapour was from three to four times the weight of air, so that any slight variation of barometric pressure could not affect the action very much. He thought that the air, instead of mixing with the vapour, acted more like a piston to force the gasoline vapour down the pipes, or, rather, to occupy the space left void in the gas fountain by the vapour falling. In the case of large buildings in France, a battery of gas fountains was placed near the roof, and the only precaution needed to insure constant supply was to put smaller pipes in the lower part of the building, because the pressure increased with the "head" of vapour, similarly to water. **N. D. Macdonald** had tested the apparatus on an autocar in which it was desirable to get rid of the difficulties and dangers of carrying liquid petrol. A regulator enabled the density of the gas to be delicately adjusted. J. Macdonald had driven from London to York, a distance of 200 miles, without any delay or accident, his motor car being fitted with a Notkin generator, which behaved beautifully in spite of a storm of hail, rain, and wind all the way. **A. Wilson** remarked that the oil used by Purves had a specific gravity of 0·65, cost 1s. per gallon, and gave 700 to 1,000 c.p.-hours ; whereas the oil he (Wilson) used at Dawsholm gas works for enriching purposes had a specific gravity of 0·85, cost about half the price, and yielded over 1,500 c.p.-hours per gallon. The difference was due to the fact that the admixture of 1 per cent. of air with petroleum gas reduced the candle-power about 6 per cent. The atmospheric pressure would be the same on the top of the system as at the burners, and would not, he thought, affect the question at all. **R. Watson** considered the apparatus was open to a rather serious objection, viz., danger of fire or explosion, besides a dis-

agreeable smell. The air was admitted through a regulator, and unless this was constructed to prevent the exit of carburetted air *by diffusion*, when the light was shut off and the downward current stopped, there would be at least the smell of the spirit used in carburetting the air. **Q. Galbraith** was of opinion that the pressure required to drive the gas through the pipes would be apt to vary with the state of the atmosphere. All the driving force available would be the difference in weight between the vaporised gas and the outside air—the one varied with the quality of the gasoline used, and the other with the weather. When both were against the gas there would be bad light, or none at all. He had had this trouble in twenty-five years' experience of machines in which air under pressure was forced through gasoline by means of weights and fans—positive mechanical appliances. **Purves,** in reply, said that in large installations at Lyons for the illumination of a hospital, barracks, church, and college, the gas fountains were stored in the upper part of the buildings in series battery form with a system of graduated piping, and worked satisfactorily. The weight of the vapour from petroleum, of specific gravity 0·68, being three to four times the weight of air, was amply sufficient to produce a flow and overcome the friction in the pipes with curved bends—sharp ones being avoided. With the most suitable petroleum, of 0·65 to 0·66 specific gravity, the weight of vapour was 2¾ times the weight of air. As to motor cars, the difficulties raised by Murray had been got over by a special carburetter and regulator. On the 6-h.p. Daimler motor it was usual to take one gallon of petrol for a run of 20 miles. On the run from London to York the petrol used amounted roughly to half a gallon per 20 miles. The residue was small, and the clogging up of the absorbent very trifling. The absorbent cost 5s. to 6s. per cwt., so that the cost of filling the box was a fraction of a penny. A gallon of the most suitable petroleum should weigh 6·5 lbs. A blue and inefficient light only could be obtained from paraffin; and one of the lighter and more volatile hydrocarbons must be used. He had tried, but failed, to induce a back draught so as to produce an explosion in the apparatus or set it on fire. The carburetters on motor cars were 2 feet in length by a foot square, and each held three gallons of petroleum. When one was exhausted, as indicated by the reduction in the power of the engine, another could be used. W. R.

1174. *Explosive Power of Acetylene.* **R. H. Fenn.** (Eng. News, 44. pp. 366–367, 1900. Condensed from a graduating thesis presented at the Clarkson School of Technology, Potsdam, N.Y.)—Photographic views are given of the cylinder and apparatus for testing the pressure of explosive mixtures of gas and air, including a gauge reading to 100 lbs. per square inch for initial pressure, an induction coil and sparking device to explode the mixtures, and a Crosby indicator using a 300-lb. spring with barrel belted to a revolving shaft giving a card with a continuous line for the rise and drop of pressure. A small generator produced the acetylene, each charge of which was measured over water in a calibrated bottle.

Experiments were made at initial atmospheric pressure with mixtures ranging from 15 parts by volume of air to 1 part of acetylene, to 3 parts air to 1 part acetylene. The 3 : 1 mixture showed very markedly the poor combustion due to lack of air, a heavy black soot being driven out of the cylinder on exhausting. A mixture of air to gas in the ratio of 9 : 1 gave the greatest explosive pressure, 112 lbs. per square inch. This was increased to 350 lbs. when the initial pressure before ignition was increased to 35 lbs. per square inch.

For comparison, a series of tests were made with mixtures of air and vaporised gasoline in the ratio 4 : 1, which gave the greatest explosive pressure, 165 lbs., at initial pressure of 20 lbs. At the same initial pressure the 9 : 1 mixture of air and acetylene produced a pressure $\frac{273}{165}$ greater than that by the gasoline, so that the volume of acetylene to give the same pressure need only be $\frac{1}{2} \times \frac{165}{273} = 0{\cdot}304$ of the gasoline.

Taking the theoretical indicator diagrams for the explosion of these two mixtures, the area of the acetylene diagram measured 4·91 square inches, and that of gasoline 1·79 square inches, giving a ratio of power nearly 3 : 1. Indicator diagrams show that the time-rate of the acetylene explosion is five times faster than that of the mixture of gasoline and air. A large quantity of heat is absorbed by the iron walls about the gas, thus reducing the maximum pressure, which is a function of the heat evolved by the explosion. As vaporised gasoline acts more slowly than acetylene, the practical test makes acetylene (mixture 9 : 1) 3·28 times more powerful than gasoline (ratio of 4 : 1), whereas theoretically it should be only three times as great.

The calorific value of the acetylene used was 1,350 thermal units and that of gasoline 700 heat units per cubic foot. A cubic foot of each of the above mixtures at initial atmospheric pressure would give 90 lbs. and 43 lbs. per square inch respectively. Allowed to expand adiabatically to 10 cubic feet, the calculated external work,—

$$W = \frac{p_1 v_1}{K-1}\left\{1 - \left(\frac{v_1}{v_2}\right)^{K-1}\right\}, \text{ (where } K = 1{\cdot}405),$$

would be for acetylene 22,403 foot lbs., and for gasoline 12,132 foot lbs. But only 0·0625 cubic feet of acetylene was used, while 0·20 cubic feet of gasoline was needed, or 3·2 times as much. With the given ratios of mixtures only 0·0312 cubic feet of acetylene is required to do the same work that 0·20 cubic feet of vaporised gasoline will do. Or comparing equal quantities of the two gases, acetylene has about 6·5 times the intrinsic energy of vaporised gasoline at the given ratios of air and gas.

Assuming an engine of total efficiency from fuel to useful work of 15 per cent., and a consumption of 22 cubic feet of gasoline gas per h.p. per hour, the cost of 1 h.p.-hour would be 0·65d. (1·3 cents), at 2s. 5d. (58 cents) per 1,000 cubic feet of vaporised gasoline. The cost per h.p. per hour for acetylene in an engine of equal efficiency would be 1·3d. (2·6 cents), with acetylene 33s. 4d. (8 dollars) per 1,000 cubic feet. To do the same work with acetylene in place of vaporised gasoline, therefore, would be about twice as expensive. For this reason acetylene would only be of practical use to produce power where light compact engines were required, as in automobiles. In the event of a 50 per cent. reduction in the price of calcium carbide, however, it might probably come into more general use for gas engines. W. R.

AUTOMOBILISM.[1]

1175. *Cooling of Explosion Motors.* (Horseless Age, 6. pp. 17–19, 1900. Extracts from the report of **Grouvelle** and **Arquembourg** at the International Congress of Automobilism of 1900.)—The report describes the methods

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

at present in use for keeping the temperature of the cylinder walls of explosion motors within the limit at which the lubricating oil commences to decompose, viz., from 350° to 400° C. For cylinders developing up to 3 b.h.p. deep ribs, either cast with or suitably attached to the body and head, enable a sufficient surface to be exposed to the air to carry off the heat by radiation alone. For higher powers it is necessary to carry off the heat by means of water circulated in the cylinder jacket either by thermo-syphon action between the hot water in the jacket and the cooler water in a tank placed at a higher level than the cylinder; or by circulating the water by means of some form of pump. This pump is usually of the simplest possible centrifugal type driven by friction from the periphery of the engine fly-wheel. The authors mention two pumps of their own manufacture for which the capacities are as follows: (1) Diameter of fan 2 inches, speed 2,500 to 3,000 r.p.m., volume delivered 9·75 gallons per minute, for motors up to 6 b.h.p. (2) Diameter of fan 3¼ inches, speed 2,000 to 2,500 r.p.m., volume delivered 13·75 gallons per minute at a maximum pressure of 30 feet of water, for motors from 6 to 20 b.h.p. For this pump the supply pipe is ¾-inch bore, and delivery ⅝-inch bore. In the return water circuit between the engine and the water tank it is customary to employ a radiator or cooler mounted in an exposed position on the car and presenting as large a surface as possible to the air, for the purpose of dissipating the heat abstracted from the engine cylinders, and preventing the temperature of the water in the supply tank from reaching boiling-point. The radiator is usually composed of copper piping, to which thin radiating ribs of aluminium or iron are attached. The authors mention three sizes with pipes ½-inch, ⅝-inch, and ¾-inch bore respectively, having radiating surfaces of 0·84, 0·80, and 0·89 square feet per foot length. The radiating surface required per b.h.p. is not stated. C. R. D'E.

1176. *Turrell Gasolene Carriage.* (Horseless Age, 7. pp. 21–24, Jan. 16, 1901. From the Autocar.)—A description of a two-seated carriage propelled by a 7-h.p. two-cylinder horizontal engine mounted at the front of a channel steel underframe designed with a view to securing some flexibility between its front and back members. The power is transmitted from the engine shaft by means of a long belt to the change-speed gear, which consists of spur pinions gearing with spur wheels mounted loose on the exterior of the differential gear box sleeve on the live rear axle. By means of a special system of keying, any one of the spur wheels may be caused to drive the differential sleeve, and in this manner three forward and one reverse speeds may be obtained. Side elevation, plan, and end elevation of the engine show the disposition of the cylinders, crank-shaft and connecting rods, adopted to secure accurate balance and compactness. The sliding key system of the change speed gear is also clearly shown. C. R. D'E.

1177. *Automatic Tension Belt Transmission for Automobiles.* (Horseless Age, 7. pp. 23–25, Jan. 30, 1901. From the Zeitschr. Automobilen-Industrie und Motorenbau.)—This article describes a form of belt transmission in which the belt tension is automatically adjusted in proportion to the work to be done. In the arrangement of mechanism illustrated, the motor is placed at the front of a rectangular underframe with the crank-shaft in the direction of the length of the frame. The power is transmitted through a friction clutch to a change speed gear which drives a transverse shaft, having at its end belt pulleys from which are driven short independent shafts carrying spur pinions gearing with spur-wheel rings on the driving road wheels of the car. These

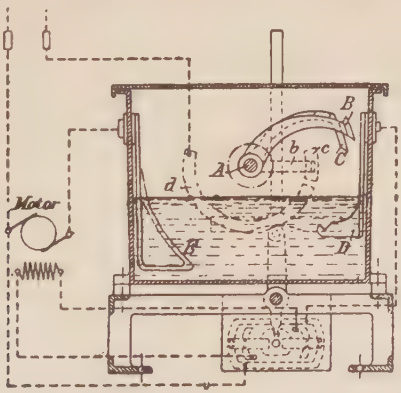
short shafts are so mounted that they may turn about the rear axle without disengaging the final spur drives. To give a normal tension to the belt, helical springs are suitably arranged to pull the spur pinion shafts away from the change gear cross shaft. When the engine power is applied, the tendency of the spur pinions to rotate round the spur wheel rings in the opposite direction to the rotation of the road wheels exerts an automatic tension on the belts varying in proportion to the power transmitted. This arrangement also obviates the use of a special differential gear. C. R. D'E.

1178. *Rubber Tyres.* **M. Michelin.** (Horseless Age, 7. pp. 21–26, Jan. 2, 1901. Paper read before the International Automobile Congress.)—There are four classes of tyres: (1) Solid tyres put on the rims by force, (2) cemented, (3) wired, and (4) fastened by bolts. Pneumatic tyres deal with obstacles up to 1¼ inches; springs up to 4 inches. On motor cars pneumatics are chiefly valuable in preserving the life of the machinery. A steel wheel rolling on steel ground would have its speed increased if provided with a pneumatic tyre. But the author deprecates making any formulæ about roads, and relies entirely upon trials. He has found a solid rubber tyre better than iron on wood or snow-covered ground, but inferior when the road is hard and smooth. An electric cab was run 2 km. on solids at an average speed of 13·94 feet per second, and the energy taken was 1,037,680 watt seconds. The same cab, with four pneumatics, made the same distance in the same day with 817,840 watt seconds (diameter of wheels not given). Another experiment was made with 17·9 per cent. energy economy, and 5·3 per cent. gain in speed. The starting pull on a dead level was found to be 14 per cent. lower with pneumatics, the trial being effected by weights added to a pan connected to the car through a pulley. Mauny states that in transporting 1 ton of useful load a wear of 4 grammes of iron per kilometre was lost. The wear of a pneumatic tyre depends on small factors, for example, on steering-wheels; the play of a bad steering-gear increases the wear appreciably, as does also the slip of the tyres when the brakes are applied. The effect of dishing the wheels on the wear is remarked upon. The dishing of the front and rear wheels on the Darracq is 6 per cent. and 3 per cent. respectively, Peugot 2 per cent. and 4·7 per cent., Dietrich 3 per cent. and 6 per cent., and on the Panhard 4 per cent. Armoured tyres and self-healing tyres do not seem to be practicable. M. O'G.

GENERAL ELECTRICAL ENGINEERING.

1179. *Accumulator Acid.* **R. Heinz.** (Centralblatt für Accumulatoren, 2. pp. 35–36, Feb. 1, 1901.)—Sulphuric acid for storage cells must be very pure. It should be quite free from the metals that are precipitated by sulphuretted hydrogen, especially lead. The amount of iron should not exceed 0·01 per cent., nor that of chlorine 0·002 per cent., and of nitrogen, in whatever combination, the quantity should not be greater than 0·1 per cent. It should not have any organic impurities, and should be free from sulphuretted hydrogen. The author has had a long experience of the manufacture of sulphuric acid, and especially of acids used in accumulators, and finds that much impure acid is in use. Brimstone acid is usually free from arsenic, but sometimes traces are found. Acid made from sulphur obtained as a by-product from sulphuretted hydrogen can be depended upon as arsenic free. Such acids when concentrated in the usual platinum or platinum-gold apparatus are as a rule very pure, and contain only traces of metallic impurities, and when diluted with *pure* water are very suitable for accumulator use. W. W. H. G.

1180. *Motor Starting-Switch.* **F. R. Dietze.** (Elektrotechn. Zeitschr. 22. 154–155, Feb. 14, 1901.)—This switch, which is combined with a resistance, is made by Flohr of Berlin, and is intended to give a very steady



increase of current on starting the motor. It is mainly used in connection with lifts and cranes. The action of the switch can be understood from the accompanying drawing, which also shows the connections. At the bottom of the diagram is shown the commutating switch, which changes the direction of the current through the magnet coils. As soon as this switch is closed, the starting resistance is operated automatically; though in some forms of the switch the starting resistance is varied by hand. The resistance material is graphite, which is contained in a box, shown at the top of the drawing, and the revolution of the shovel-shaped pieces, B and C, closes respectively the circuits of the armature and magnet coils. The piece C comes eventually in contact with D, and the coils then receive the full working pressure; the

armature similarly receives the full voltage when B comes in contact with E. It is claimed that by this device the sparking and racking are much diminished, in consequence of the fact that the increase and decrease of the current is very steady, and that at the moment of breaking circuit no sparking occurs, seeing that the current is then extremely small. W. H. S.

1181. *Tests of Magnetic Circuit-Breakers.* **H. A. Brown.** (Elect. World and Engineer, 37. pp. 229–230, Feb. 9, 1901.)—Tests made to determine the time required for circuit-breakers to operate, and the maximum value of the current attained, show that current × (time − K) = a constant. The value of K varied from 0·005 to 0·023 with different circuit-breakers, and the time, with 100 per cent. more than the normal maximum load, from 0·042 to 0·078 seconds. A. H. A.

1182. *Brake Electromagnets for Electric Cranes.* **M. Vogelsang.** (Elektrotechn. Zeitschr. 22. pp. 175–177, Feb. 21, 1901.)—An illustrated description of a shunt-wound, iron-clad, brake-releasing magnet, provided with an automatic switch by means of which the resistance in series with the magnet-winding is short-circuited when the magnet is not excited. Hence, on closing the circuit, a very large current passes through the magnet coil, enabling it to exert a strong pull on the plunger, in spite of the long air-gap. The plunger, in rising, opens the short-circuiting switch, introducing the resistance into the short circuit, and reducing the exciting current to a safe limit for continuous working. A. H.

1183. *Thury Electric Time-distribution System.* **J. Reyval.** (Écl. Électr. 26. pp. 245–250, Feb. 16, 1901.)—In this system, the master-clock consists of a continuous-current motor supplied with current from accumulators and driving a polyphase dynamo, the speed of which is controlled by a centrifugal governor breaking a negatively wound circuit on the field magnet when the speed exceeds a predetermined value. The polyphase dynamo drives synchronous motors actuating the secondary clocks. The original paper is illustrated. C. K. F.

1184. *Immersed and Water Rheostats.* **B. P. Rucker.** (Amer. Electn. 13. pp. 72–74, Feb., 1901.)—The author points out the very variable resistance of water rheostats, giving curves between current and time for solutions of various salts. The resistance decreases rapidly to a minimum at boiling-point, after which it increases with time. The limit of power continuously absorbed with a 40-gallon barrel is 15 h.p. Experiments were made with spirals of iron wire immersed in water, according to which 100 h.p. was easily dissipated in the same space; there were nine coils of No. 12 galvanised iron wire, each having a resistance of 0·737 ohm when hot, and a stream of water was kept flowing. Other experiments are described, having for their object the prevention of electrolytic corrosion. In order to obtain fine adjustments, a plate rheostat may be used in series with the coil rheostat. A table of suitable sizes and lengths of wire for various currents is given (at 110 volts), from which it appears that the safe capacity in water is about 14 times the capacity in air. A. H. A.

1185. *Electric Drawbridge.* **H. G. Tyrrell.** (Elect. World and Engineer, 37. pp. 265–266, Feb. 16, 1901.)—Description of a new bridge across the Connecticut River at Middletown. Roadway 26 feet wide traversed by

electric railway. Bridge 1,300 feet long, consisting of two spans of 200 feet, two of 225 feet, and the draw span of 450 feet. The drawbridge is operated by three 25-h.p. electric motors. H. R. C.

1186. *Electric Driving of Printing Machinery.* (Engineer, 90. pp. 41–43, 1900.)—The saving in space, cleanliness, and ease of stopping are the important advantages. Stopping is effected by a number of bell pushes which short-circuit an electromagnet on each starter. Sixteen or twenty newspapers are being worked electrically. Holmes uses two motors to each rotary web press; one may be 25 h.p. and the other 3 h.p. The machine shaft has a cast-iron toothed wheel driven by a brass pinion on the shaft of the large motor, which is prolonged on the side away from the press and carries one half of a crown wheel clutch. The clutch is worked magnetically, and the other half of it, which is of gunmetal, is carried on a shaft to which is keyed a worm wheel driven by a worm from the smaller motor. Through this worm the small motor effects the small speeds and slow movements of the press. The printing cylinder can thereby be moved through small angles without difficulty. The switch involves a large number of contacts, over which passes a sliding contact-piece moved by means of a worm and wheel. When the top speed is to be gained, the big motor takes up the load, by its speed gaining on that of the auxiliary motor, and pushes out the self-releasing clutch, the backward movement of which cuts out the small motor electrically and mechanically. The number of copies per hour turned out with 200 volts and 104 amperes is 48,000.

The Republic Newspaper of St. Louis takes current from the public supply, because the load-curves show that the bulk of the load occurs between 5 a.m. and 5 p.m., with a peak at 2 p.m., this being a desirable load for the power station. Three Hoe quadruple presses are driven by a motor running at 700 r.p.m., arranged by gear wheels to be below the floor; the slow speeds are obtained by a small motor-driven dynamo which delivers a potential varying between zero and 80 volts to the main motor. Each press has a 40-h.p. motor to allow for extensions to the press, which at present takes 30 h.p.

Each of the 20 Mergenthaler Linotypes is driven by a $\frac{1}{4}$-h.p. motor with worm gear. Powerful arc lamps are used in the art department for photographic work. The stereotype machine is driven by a $2\frac{1}{2}$-h.p. compound-wound motor at 450 revs. The trimming saw is driven by a 4-h.p. motor at 1,400 revs. The shaper, which is used for shaping the curved interior surface of the stereotyped plates, takes 4 h.p. The pneumatic tube delivery system is supplied from a blower driven by a 4-h.p. shunt motor.

The Cutler-Hammer press-drive employs but one motor. A simplified diagram is given of the connections as well as a working diagram, the shunt being automatically controlled by means of solenoids. If a sudden load is thrown on the motor, the solenoids act and open the circuit shunting the armature, thus preventing it from stopping. If the motor load falls off too rapidly for control by the central dash-pot solenoids, other solenoids come into play and short-circuit some of the shunting resistances. At top speeds the solenoids are thrown out of gear. This method is complicated, but is said to work well. [See further Abstract No. 1747 (1900).]

The electric installation of Alabaster, Pasmore & Sons, of Whitecross Street, London, is briefly described, two 35-h.p. gas engines being the motive power. Six lithograph presses are driven separately by either 2- or 3-h.p. motors according to size. The noise is said to be negligible. M. O'G.

1187. *Insulating Power of Snow.* **B. Brunhes.** (Comptes Rendus, 132. pp. 465–466, Feb. 25, 1901.)—Lespieau and Caurs on Mt. Blanc and Ricco on Mt. Etna have already shown that snow seems to be an insulator, since bare wires placed on the snow continue to transmit telegraphic and telephonic messages. The author describes two distinct tests on the same point which he made on the line to the summit of the Puy de Dôme.

(1) When a line is broken by wind, it is not necessary to raise and insulate it from the snow; the author merely attaches temporarily a wire to each broken end and leaves the intervening bare wire on the snow.

(2) In the severest winter weather the posts and their insulating cups and the wires are surrounded by a solid sheath of hoar-frost as much as ½ m. in diameter. Thus the wire is joined to the ground *by snow*, yet the insulation remains perfect. P. E. S.

1188. *Polyphase Currents.* **A. Potier.** (International Physical Congress at Paris, Report, 3. pp. 197–263, 1900.)—This report describes the main applications of polyphase currents to actual work, and contains many valuable and useful discussions of practical problems, generally from the point of view of the physicist. In transmitting power by polyphase currents to a given distance, the author proves that if R be the resistance in parallel of all the copper mains used, W the power generated, and V the potential difference between each main and earth, then, whatever the number of phases, the ratio of the power lost in the main to the total power—

$$= \frac{RW}{V^2 \cos^2 \phi},$$

where $\cos \phi$ is the power factor of each main. Hence, whatever the number of phases, the loss for the same power-transmission is the same if the p.d. beween each main and earth is the same. When we keep the p.d. between consecutive mains the same, then this is not true. In this case the weight of copper in the three-phase is to its weight in the single phase, as 75 is to 100. If we admit that the difficulties of insulating cables depend on the p.d. between the mains, then this would explain why the three-phase currents are nearly invariably employed for long-distance transmission. If E be the p.d. between adjacent wires, then for direct current the percentage loss is $\frac{4RW}{E^2}$ and for three phase $\frac{3RW}{E^2 \cos^2 \phi}$. Remembering that in practice $\cos \phi$ generally lies between 0·7 and 0·8, it will be seen that the advantage is in favour of continuous current.

An excellent description is given of how the magnetic field glides round the air-gap between the rotor and the stator of an induction motor. It is proved that if the currents follow the harmonic law, and if the radial magnetic forces at points round the circumference of the rotor due to constant currents in any of the windings also follow a harmonic law, then the magnetic field is sinusoidal, and glides round the air-gap with uniform angular velocity. Great stress is laid on the importance of the artifice of substituting fields rotating in opposite directions for fixed oscillating fields, and the properties of these rotating fields are fully considered.

A fairly complete theory of the working of asynchronous motors is given. The author states that the leakage factor (σ) is about 0·1 in good machines. The action and parallel working of polyphase alternators is discussed. The following method is given of telling the relative speeds of two three-phasers

when being synchronised. A small three-phase transformer is connected across the terminals of each machine. Let 1, 2, and 3 be the three secondary circuits of the first transformer, and let each of them be put in series with the corresponding circuit of the second transformer through a lamp. If the incoming alternator is running slower than the other, then the lamps attain their maximum brilliancy in the order 1, 2, 3; if it is running quicker than the other, then the rotation takes place in the reverse order 3, 2, 1. [See Abstract No. 892 (1899).]

Proofs of the methods of converting from one polyphase system to another by transformers are given. Formulæ are also found for rotary converters and permutators. The author concludes by describing Leblanc's system of using asynchronous machines as generators [see Abstracts No. 746 (1900), and No. 576 (1901).] If we have several machines of this type, it is sufficient that their polyphase windings receive currents from the same source in order to ensure that the induced electromotive forces should all have absolutely the same period. Hence the paralleling of such machines could be done as easily as that of direct-current dynamos. The machine which supplies the polyphase currents and thus sets the time to the other machines may be quite small. The author compares its *rôle* to that of a *chef d'orchestre.* A. R.

REFERENCES.

1189. *Lightning Conductors.* **F. Findeisen.** (Elektrotechn. Zeitschr. 22. pp. 139–145, Feb. 7, 1901.)—This paper is a detailed reply to the discussion on the author's publication, "Hints on Protection from Lightning," at the meeting of the Elektrotechnische Verein, held on May 22, 1900. [Abstract No. 2099 (1900).] The publication contained the results of the investigations carried out by a committee appointed by the Society. G. H. B.

1190. *Standardisation of Edison Screw Sockets.* **R. Hundhausen.** (Elektrotechn. Zeitschr. 21. pp. 921–924, 1900.)—Report of the German Commission on the subject.

1191. *Steam Heating from Central Stations.* **W. H. Bryan.** (Eng. News, 45. pp. 109–112, Feb. 7, 1901. Abstract of a paper read before the American Soc. of Heating and Ventilating Engineers, N.Y., Jan. 22–24, 1901.)—The suggested arrangement is that a central electricity station should also supply heat by means of steam-pipes, using the exhaust steam from the engines and, when this is not sufficient, live steam in addition. [The economy of the engines seems throughout to be considered of quite minor importance.] H. R. C.

1192. *Electrical Machinery in Coal Mining.* **W. C. Mountain.** (Elect. Rev. 48. pp. 239–243, Feb. 8, 1901.)—This is a short paper dealing generally with the application of electrical power in coal mining, showing the plant used, the capital outlay and saving achieved in actual cases in British practice. Various types of reciprocating and rotary pumps, haulage engines, and coal cutting machines, are described. The paper is illustrated with admirable reproductions from actual photos. Ll. B. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

1193. *Rating of Tramway Motors.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 134–137. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 92–94 and 201–206.)—**C. H. Macloskie,** the author of the report, proposes as a definition of the power of a motor, the power supplied in kilowatts when the motor is working on a load such that its temperature after one hour will be 75° C. above that of the surrounding air. As an indication of the speed, he proposes a constant depending on the current, and the tractive effort on the rim of the wheels. The curve of a tramway motor between current and effort is practically a straight line, if only the working portion be considered, and may be represented by—

$$x = ny - m, \text{ or } y = \frac{x}{n} + \frac{m}{n}$$

where y is the current, x the tractive effort in kilos, and m and n are constants.

The author writes $y = A\,\frac{x}{1000} + B$, and proposes to complete the rating of a motor by the constants A and B. B would represent the idle current of the motor if the curve were a straight line throughout, and gives some indication of the losses. A represents, in milliamperes, the current required per kilo of tractive effort at the wheel-rims, and determines the speed of the motor for a given wheel diameter, which the author takes as 800 mm. The speed in kilometres per hour is given by—

$$146\left\{\frac{A}{1000}\cdot\frac{d}{800} + \frac{B}{x}\right\},$$

assuming an efficiency of 80 per cent., d being the wheel diameter in mm. Knowing A and B, the current required to give any tractive effort can be found from the first formula. The author then proposes to rate a motor by three figures, the first being the power in kw., as defined above; the second, A; and the third, B. On this system, for example, the Thomson-Houston motor G.E.-51-B-6 would be rated by 70-162-29, and the motor G.E.-62 by 26-91-18. The weight of a motor is approximately $5000\,\frac{B}{A}$.

Discussion.—**D'Hoop** considered that the conditions under which the power of the motor is determined should be more precise. **Hospitalier** proposed a different system of rating; as the speed increases, the power of the motor passes a maximum value; this maximum should be taken as the normal power of the motor, which is further defined by the following factors: the maximum couple at starting, the speed and the couple corresponding to the maximum power, and the speed at which the couple vanishes.

G. H. B.

1194. *Measurement of Slip in Induction Motors.* **G. Seibt.** (Elektrotechn. Zeitschr. 22. p. 194, Feb. 28, 1901.)—The difficulties connected with the accurate determination of the slip from the speeds of the generator and motor are sufficiently well known. An accurate measurement is only possible

with a method which measures the slip directly, and not as the difference of two quantities, each of which is large in comparison with the slip. The author suggests the following method, which is applicable to short-circuited as well as to wound motors. A Joubert contact-disc provided with a contact-piece of suitable width is fixed to the shaft of the rotor. In series with this is joined an incandescent lamp, the entire circuit being connected across two of the supply mains. The lamp will light up or grow dim according as the interval of contact happens to be in the neighbourhood of the maximum or the zero value of the p.d.-wave. The frequency of the light fluctuations determines the slip if the speed of the motor is known. Instead of the lamp, a voltmeter, or—better still—a Morse instrument may be used. The method has been tried by the author with very satisfactory results. A. H.

1195. *Rotary Converters.* **W. E. Goldsborough.** (West. Electn. 28. p. 86, Feb. 2; Discussion, pp. 102–103, Feb. 9, 1901. Paper read before the North-Western Electrical Association at Milwaukee, Wis., Jan. 17, 1901.)—A simple non-mathematical explanation from first principles is given of the theory of rotary converters. The author points out the apparent paradox that a large part of the alternating current never enters the machine at all, as twice in every oscillation of the alternating current the direct current entirely neutralises the alternating current in the windings of the armature. Outside the armature windings, however, the direct and alternating currents at these times are flowing in the same direction. Steinmetz's table [Abstract No. 758 (1899)], giving the comparative capacity ratio of different types of synchronous converters, is quoted. Stress is laid on the fact that a synchronous converter acts like a condenser or a choking coil according as the field magnets are over- or under-excited. This fact is made use of to improve the power factor of the station load. The field excitation should be so adjusted at light loads as to promote lagging currents in the system, *i.e.*, the converter fields should be under-excited. With this adjustment, as the load comes on, the series winding by strengthening the field will improve the power factor until it is 100 per cent. at full load. A frequency of sixty is the upper limit of the frequency for practical working. The best results are obtained with frequencies between 25 and 40. The inductance of the armature should be high. This means that the coils are placed in deep slots, and that teeth with projecting heads are not objectionable. If the inductances are low the machines are liable to hunt. In starting synchronous converters from the alternating current side, the exciting circuit should be opened, and it is advisable to disconnect the field windings from each other, as the excessive voltage sometimes induced in them breaks down the insulation. Boosting transformers are often used at starting so as to prevent large starting currents causing voltage fluctuations in the distributing system. When a converter is started from the alternating current mains, an alternating e.m.f. is apparent at the commutator brushes, the frequency of which diminishes as the speed increases. Lamps connected across the brushes show by their pulsating light the degree of synchronism attained. When synchronism is attained the load is put on the converter.

Discussion.—**H. J. Gille** asked if the figures given in Steinmetz's table were true at all loads. He also said that he had found trouble with rotary converters, as they often caused the mains to become unaccountably hot. **D. C. Jackson** said that it was a practical impossibility to get unity power factor with a rotary converter or any other synchronous type of machine run under ordinary conditions. In the first place there was always a slight

amount of "hunting" or wobbling of the armature, and in the second place the shape of the p.d. wave was never an exact copy of the shape of the current wave.

In his reply the author stated that Steinmetz's table was only true for sine-curve waves and for light loads. He suggested two explanations of the heating of the mains mentioned by Gille. The first, that it was simply a Kelvin effect, the current repelled to the circumference of the cable making the current density near the circumference too great. The second explanation was that it was caused by difference of wave form between the alternator and the converter e.m.f.'s, so that idle currents flowed between the two machines simply to fill in the gaps in the wave forms. A. R.

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1196. *Electrical Machinery at the Paris Exhibition.* (Electrician, 45. pp. 470–473; 507–510; 550–554; 663–666; 694–697; 768–772; 844–848; and 886–888, 1900.)—Articles describing the most important machines exhibited, and containing several drawings showing details and general arrangements.

1197. *Short-Circuited Rotors of Induction Motors.* **M. Osnos.** (Elektrotechn. Zeitschr. 22. pp. 172–175, Feb. 21, 1901.)—The author deals with the effect of the end-rings in increasing the resistance of the rotor bars, and compares the relative amounts of copper required for end-connections, for the same increase of resistance, in the case of a short-circuited and a wound rotor. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1198. *Cost of Power.* **J. B. C. Kershaw.** (Elect. Rev. 47. pp. 496–499, and 563–564 ; Discussion, p. 564, 1900. Paper read before the British Association.)—The author has collected a variety of statistics bearing on the cost of power in different parts of the world. Dealing first with steam power, the figures vary from £3 12s. 10d. per i.h.p.-year of 8,760 hours to £26 5s. 1d. The former figure is given by Dawson as being the cost in large tramway stations, while the latter figure refers to Siemens' Woolwich works. Siemens' figure is, however, very much higher than any other figure quoted, the ordinary price in England and America appearing to be in the neighbourhood of £6. Raworth estimates the cost with superheated steam and modern engines and boilers, used on a large scale, to be £3 14s., and this figure has been verified in certain cotton mills where coal is cheap. Much obviously depends on the cost of coal, and comparisons are not always possible. Coming next to water-power, the figures are given per e.h.p.-year. They vary from £1 in Norway to £26 11s., which is the charge to small consumers in Buffalo. Here again comparisons are difficult, inasmuch as in some cases the actual operating costs only are given, and in other cases the charges to consumers. With regard to gas-power, estimates only are given. Meyer estimates that power produced by blast furnace gases would cost £4 1s. 7d., and with Mond producer gas Humphreys puts the figure at £5. Comparing these figures in so far as any comparison is possible, it would appear that under favourable conditions water-power is much the cheapest. But generally the conditions are not favourable, and immense expense has to be incurred either in hydraulic engineering or in transmitting the power generated over a considerable distance, or in both. The author states that power from water is costing more in Rheinfelden, at Zurich, and at Buffalo than it would do if generated by steam in Lancashire. The paper contains much useful information, and the authorities for the various figures are in all cases given.

W. H. S.

1199. *Determination of the Price of Electric Energy Supplied from Central Stations.* **K. Wilkens.** (Elektrotechn. Zeitschr. 22. pp. 116–118, Feb. 7, 1901.)—After giving curves and diagrams illustrating the variation of the load during the 24 hours and throughout the year, the author deduces the following equation for the prime cost k of unit energy for the separate consumers :—

$$k = \frac{C m}{A} + s,$$

where A = the amount of current taken in a year by a given consumer ; C = Z/M, where M = the sum of the currents taken by the whole of the consumers at the time of maximum load at the central station, and m = the current taken by the given consumer at this time ; Z = the total expenses for interest and depreciation ; and s = cost of generating one unit of current. This equation is then applied to different classes of consumers with the figures obtained from 26 continental stations, which are given in a table. The mean values so obtained are as follows :—C = 35,600, since for each kw.

supplied to the consumer at the time of maximum load, 3,560 m. capital must be expended, taking 74 per cent. as the ratio of the useful energy to the total energy generated ; $s = 13{\cdot}53$ pfennig. Thus where $m = 140$ kw. and $A = 115{,}000$ kw.-hours, $k = \frac{35{,}600 \times 140}{115{,}000} + 13{\cdot}53 = 56{\cdot}9$ pf., and k' = selling price, reckoning 10 per cent. profit on the current supplied, is given by $k' = \frac{35{,}600 \times 140}{115{,}000} + 1{\cdot}1 \times 13{\cdot}53 = 58{\cdot}2$ pf. A number of other examples are given in the original paper. C. K. F

1200. *Regulation of Potentials to Earth of Direct-Current Mains.* **A. Russell.** (Inst. Elect. Engin., Journ. 30. pp. 326–344, Feb., 1901.)—In the case of three-wire distributing networks, the potential of the outer above that of the earth is generally much higher than the difference of potential between adjacent mains. When, therefore—as is almost invariably the case nowadays—the difference of potential between the outers exceeds 250 volts, it becomes necessary to adopt means for preventing the potential from earth of any main from rising above this limit. The author considers how the potentials depend on the fault resistances of the mains, and what methods should be adopted for regulating them. He gives the following elegant graphical construction. Take a straight line, and choose three points in it, P, M, and N, making PM = MN = p.d. between adjacent mains. Let f_1, f_2, and f_3 stand for the fault resistances of the positive, middle, and negative mains respectively. Imagine masses $\frac{1}{f_1}$, $\frac{1}{f_2}$, and $\frac{1}{f_3}$, placed at P, M, and N respectively. Find the point G in the straight line, which is the centre of gravity of these masses. Then PG, MG, and NG give the potentials from earth of the three mains respectively. The author next considers the following methods of keeping down the potential of the positive outer : (1) Earthing the positive outer through a resistance ; (2) earthing the middle main through a resistance ; (3) earthing the middle main through a battery whose positive is earthed. The earth connection should be removable, so as to allow of the measurement of the insulation resistance of the network. The author deduces expressions for the maximum value of the leakage currents when the middle wire is earthed through a known resistance, and determines the limits between which the leakage watts must lie. A. H.

1201. *Electric Regulations in Various Countries.* **L. Gerard.** (Soc. Belge Élect., Bull. 17. pp. 495–503 ; Discussion, pp. 503–505, 1900.)—The war between telephone and telegraph interests and traction and lighting interests would have been less bitter if the question as to payment of costs had been definitely decided. In France the administration imposes strict rules, and makes private companies double their telephone lines, &c., at their own expense. In Germany there is no law, and each case is considered on its merits. In Switzerland a very practical law has been passed decreeing the proportions in which costs are to be borne. Telephone lines are doubled at the sole cost of the State.

The minimum distance permissible between a telephone line and a parallel power or lighting line is 2 metres in France, 20 metres in Germany. Two metres is evidently too small in the case of polyphase currents. Lines above 1,000 volts are required to have guard wires underneath in Germany and France, but in Switzerland there is no rule. In Germany the smallest per-

missible conductor is 10 sq. mm.; in Switzerland it is 22 sq. mm. In Switzerland spans may not exceed 45 metres; in Germany no limit is given.

In the three-phase tramways at Lugano the third conductor was originally the uninsulated rail, but this caused much trouble with the telephone and telegraph wires. The third wire is now insulated, and the trouble is removed.

E. H. C.-H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1202. *The Central London Railway.* (Electrician, 45. pp. 210–212; 276–280; 356–357; 431–433; 554–557; 730–732; 822–826, 1900; 46. pp. 538–541, Feb. 1, and 932–936, April 12, 1901.)—This is a deep-level twin-tunnel railway running between the Bank of England and Shepherd's Bush, 5¾ miles, 13 stations, with a 2½-minute service. The power-house is at Shepherd's Bush, with sub-stations at Notting Hill Gate, Marble Arch, and Post Office. The boiler-room contains 16 Babcock and Wilcox boilers, each rated at 12,000 lbs. of steam per hour at 160 lbs. per square inch, with hot feed from Green's economisers. There are four economisers, each consisting of 768 tubes, with electrically driven scraping gear. There are two chimneys, each 250 feet high by 10 feet internal diameter. The coal conveyor by C. W. Hunt & Co. consists of 200 buckets, each having a maximum capacity of 140 lbs., with a speed of 40 feet per minute. Of the 200 buckets only 20 are at any time being lifted, the others moving along the top of boilers, down the far end, and returning under the boiler-gangway. The conveyor will fill the 1,000-ton bunkers in about seven hours, and this is sufficient for a week's running. The coal descends by gravity through shoots to the mechanical stoker hoppers, which are regulated by a hand feed. Each engine is provided with a separate condenser of the Allis jet type, capable of dealing with 26,000 lbs. of steam per hour normally, or 30,000 if required. The pumps are double acting, 28 inches diameter by 24 inches stroke, and pump water from the hot well to the top of the Barnard cooling towers. There is also an auxiliary condensing plant, which takes the steam from the exciting and lighting sets, consisting of a Wheeler surface condenser of 1,900 square feet cooling surface. The engine-room contains six main generating sets, four exciter sets, and two lighting sets. The main engines are coupled to three-phase generators giving 850 kw., at 5,000 volts, 25 periods, and 94 revolutions. The engines are cross-compound Allis type, with Reynolds Corliss gears. The cylinders are 24 inches and 46 inches by 48 inches. The flywheel weighs 50 tons, and is built in eight sections. The armature, 144 inches in internal diameter, has 32 coils per phase, wound in 192 slots. The alternator has a revolving field with 32 laminated poles. Each coil has an entire slot devoted to it, and the winding of each phase is distributed into two slots per pole, this arrangement lessening the reactance of the armature. The weights are: revolving field with spider, 34,000 lbs.; complete armature, 48,000 lbs., of which the stampings account for 4,500 lbs. The excitation is at 110 volts, and the power required is 13¾ kw. The inductions are as follows: pole faces, 91,100; yoke, 54,700; and core, 50,200, c.g.s. lines. Ten sets of curves are given, showing the results of tests. The exciter sets have Allis engines and Westinghouse six-pole dynamos, and the lighting sets Belliss engines and Westinghouse dynamos. A full description of the main switchboard is given; the high-tension switches are of the Parshall aluminium double break type; the measuring instruments are of the Hartmann and Braun hot wire pattern. Each feeder panel has a bus-bar transformer ammeter in each of the three phases, also a Holden integrating

wattmeter and a Thomson recording wattmeter. There are four independent feeders from the power-house, which carry current at 5,000 volts. They are three-core, paper-insulated, and lead-covered, tested to 15,000 volts, and also to 10,000 volts for one hour, firstly between the different cores, and subsequently from the cores to earth. The leading particulars of the cables are—

	0·1875 sq. inch Core.	0·125 sq. inch Core.
Lbs. copper per cable per 1,000 feet length	2,140	1,425
Lbs. insulation per cable per 1,000 feet length.....	1,090	995
Lbs. lead per cable per 1,000 feet length	3,870	3,480
Lbs. weight complete cable per 1,000 feet length	7,100	5,900
Lbs. weight complete cable per cubic inch	0·166	0·165
Average specific gravity complete cable	4·6	4·6
Outside diameter in inches	2·125	1·94

Total weight of copper in all high-pressure cables	78·4 tons
Total length of all high-pressure cables.....	19·6 miles
Tested capacity per mile :—	
Between one core and the other two cores and sheathing	0·88 microfarads
Between one core and the other two cores alone	0·32 „
Between one core and one other core	0·23 „

Each substation is provided with seven 300-kw. transformers, two 900-kw. rotary converters, two 6-h.p. blower sets, and a switchboard for controlling the three-phase and continuous-current connections. The primaries of the transformers are connected in delta, the core is built up of plates 0·014 inch thick, each sheet being japanned separately to reduce eddy currents to a minimum. Ventilating ducts are left between the laminations at intervals of a few inches, and air is drawn through the core and coils by means of the blowers. The case of each transformer is connected through the base to a common air chamber, and the required ventilation is regulated by dampers. Five drawings and five sets of curves are given, showing the performance of the transformers ; the ageing curve shows a practically constant core loss of 140 watts for 1,300 hours.

A description is given of the substation switchboard, and the construction of the 900 kw. three-phase rotary converters. The leading particulars of the latter are :—

Number of poles	12.
Revolutions per minute	250.
Cycles per second.....	25.
Voltage on commutator	500.
Voltage at collector rings	305.
Armature core	84 in. diameter by 15 in. long.
Shunt winding	912 turns of No. 11 B & S per spool.
Series winding	8 copper strips 2·5 × 0·075 in. in parallel ; 2½ turns per spool.
Poles.....	Laminated sheet steel 12 in. square.
Yoke	Mild cast steel, 123 in. outside diameter by 22 in. long.
Armature core	Laminated iron stampings, 0·014 in. thick.
Length of pole arc	15⅞ in.

Magnetic density in poles	95,000 lines per sq. inch.
„ „ yoke	48,000 „ „
„ „ armature teeth	128,000 „ „
„ „ core below teeth	51,000 „ „
Armature winding	Multiple circuit drum.
Number of commutator segments	576.
Number of slots	288.
Size of slot	1·25 in. deep by 0·44 in. wide.
Number of conductors per slot	4.
Size of each conductor	0·4 in. by 0·125 in. = 0·05 sq. in.
Number of parallel paths through armature	12.
Number of turns in series between brushes	48.
Total cross-section of the twelve paths	0·6 sq. in.
Current density	2,400 amps. per sq. in.
Commutator	54 in. dia. by 15 in., useful length.
Commutator brushes	Carbon, 12 sets of 8 each, size $\frac{1}{2} \times \frac{3}{4}$ in.
Number of tappings for three-phase currents	18, or 3 per pair of poles.
Collector, each ring	24 in. dia. by $3\frac{1}{2}$ in. wide.
Collector brushes	Copper gauze, 8 to each ring.
Weight of armature, commutator, collector, and shaft	24,800 lbs.
Weight of magnet frame, poles, and spools	19,550 lbs.
Weight of collector, brackets, brush gear, &c.	4,000 lbs.

For surface tracks the ordinary type of bull-headed rail is used, but in the tunnel the rail is bridge section. The conductor rail is riveted channel steel, of a total length of 14·7 miles, and is supported by porcelain insulators placed $7\frac{1}{2}$ feet apart. The conductor rail is quadruply bonded with crown bonds, providing an aggregate copper section of 0·62 square inch, whilst the track rails have double bonds one on each side.

Throughout the railway, the stations are superelevated so that on leaving any station the trains start on a down gradient. This has the effect of diminishing the current on starting, whilst on approaching a station the short piece of stiff gradient diminishes the amount of braking force necessary to stop the train. It is said that this method of working has reduced the locomotive expenses by 30 per cent.

The concluding article of the series deals with the locomotives, motors, controllers and locomotive tests.

The motors, of 117 h.p. each, are series wound with the armature built up on a brass sleeve into which the axle is forced. The carcase is cast steel with four laminated poles bolted to it. Two of the coils are large and two small, the large coils being placed horizontally. The windings, with asbestos insulation, are :—

Two large magnet coils : 76 turns of strip copper, 2·12 in. × 0·11 in. ; current density, 1,000 amps. per sq. in.

Two small magnet coils : 15 turns of strip copper, 0·875 in. × 0·22 in. ; current density, 820 amps. per sq. in.

Armature : 61 slots, each 1·73 in. × 0·52 in., with single circuit series-

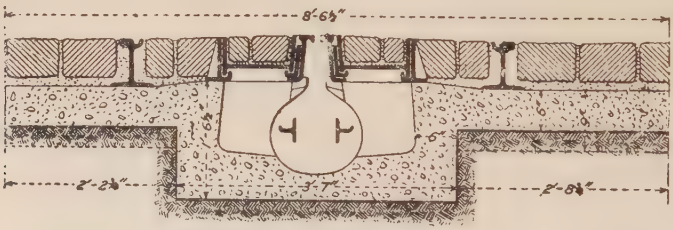
drum winding. Conductors, 0·6 in. × 0·1 in., six per slot, or 183 armature turns in all; current density, 2,100 amps. per sq. in.

Magnetic density: Armature teeth at full load, 127,000 lines per square inch.

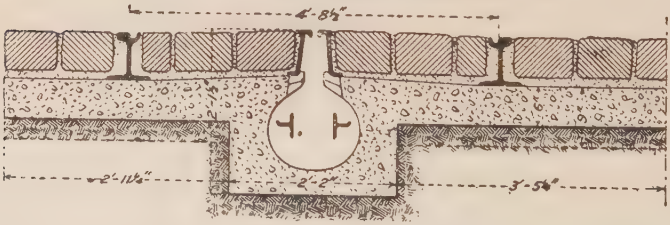
The commutator is 19 in. in diameter and 8 in. long, with 183 segments, one per turn. There are two sets of carbon brushes, with four in each set.

E. K. S.

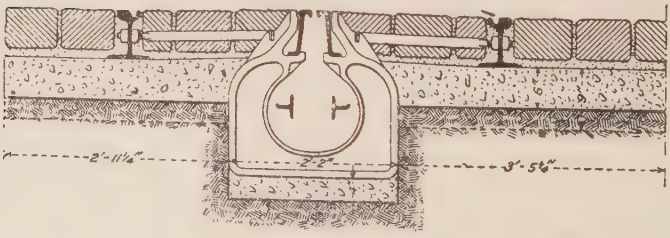
1203. *Electric Conduit for the London County Council.* (Electrician, 46. pp. 651–654, Feb. 22, 1901.)—The figures show the conduit to be used on the routes between Westminster Bridge and Tooting, Kennington Gate and Blackfriars Road, St. George's Circus and Waterloo Road. Continuous



Section through Insulator Pit and Road Box.



Section through Concrete Tube.



Section through Yoke.

current at 500 volts will be supplied from a main generating station and one substation. Double-decked bogie cars will be used, seating 64 to 70, and the speed within a 4-mile radius of Charing Cross will be 10 miles per hour. There will be double track throughout, with 4 ft. 8½ in. gauge and 102-lb. girder rails. The slot will be formed with two Z-section rails, 50 lb. per yard, with a drip lip along the inner edge of slot. The width across the two rails will be 4½ inches, and these will be bolted to the yoke jaws and further fixed by wooden wedges, the width of slot being ¾ inch. The two conductors will be soft steel tees, 23 lbs. per yard, supported on double-petticoated brown insulators at 15 feet intervals, the insulators being placed midway between yokes

on cast-iron stems cemented into the concrete. The cast-iron yokes are spaced 5 feet apart, the depth from the top of the slot rail to the bottom of conduit tube being 1 ft. 9½ in., and to base of yoke, where it bears on concrete, 2 ft. 1½ in. The greatest width of yoke is 26 inches and the section at the bottom is I-shaped, 4 inches high, 3 inches wide on the top, and 4½ inches wide on the base.

The article severely criticises the design of yoke. Experience has shown the great importance of having the slot strong to resist lateral pressure, and with this object the yokes have usually been extended out to the rails. In the L.C.C. conduit the depth of yoke from the bottom of the tube to bottom of the casting is only 4 inches, as against 7½ inches in the well-tried Westinghouse design. Wood pavement will not be allowed between track rails on account of expansion when wet. The only advantage of a small yoke is less excavation ; but as track rails are being relaid at the same time, this saving is not considerable. The clearance between the conductor rail and the bottom of concrete tube in the L.C.C. design is hardly sufficient to prevent trouble from dirt or from wet-paper when cleaning out the tube. In the earliest electric conduits, the suggested pedestal-supported insulators were tried, but were abandoned in favour of suspended insulators. The use of wooden wedges is criticised on the score of rotting and yielding under heavy traffic. Rust and vibration will gradually deteriorate any yokes, and ample margin of strength is therefore necessary. E. H. C.-H.

1204. *Northwich Electricity Works.* (Elect. Rev. 48. pp. 197–201, Feb. 1, 1901.)—This station is worked on the direct current system, and is interesting on account of the fact that Mond producer gas is used to provide the motive power. The works are situated on a piece of ground belonging to Brunner, Mond & Co., about 1,000 yards from the centre of the town. This site was chosen in view of the fact that the local gas company have a monopoly of the right to supply gas in the town, and it was thought that by placing the works on the site chosen, litigation might be avoided. Mond producer gas is supplied by Brunner Mond to the electric light company through a 12-inch cast-iron pipe which leads to a gas-holder of 2,000 cubic feet capacity. The price charged for the gas is 2d. per 1,000 cubic feet. The Mond gas is said to be remarkably clean : the sawdust scrubber requires cleansing only once a year, and it is said that although engines have been running as long as three years, not one of the pistons has ever been taken out of the cylinder. The main gas engines are by Crossley, running at 210 r.p.m. ; the flywheels weigh 8 tons, and are 8 feet in diameter. The larger dynamos are of 60-kw. capacity, by Laurence, Scott & Co., and give 125 amperes at 480 volts, being driven by belting at 600 r.p.m. There is also a set of Chloride cells, 256 in all, having a discharge capacity of 200 amp.-hours. Much trouble has been experienced in connection with the distributing system owing to the frequent subsidences caused by brine pumping. In one case a large joint box completely disappeared, and the hole, down which it disappeared, was afterwards filled up with 600 tons of cinders. The method found most effectual in dealing with these subsidences is to roughly build a second chamber outside each brick junction-box chamber, and to leave a double bend of slack cable in it. Nearly all the consumers are on the further side of the Weaver River, which is crossed by a syphon of 12-inch cast-iron pipes, the joints being made with rubber rings between the flanges. The swing bridges over the Weaver, which have been already described [see Abstract No. 2092 (1900)] are supplied with power by the electric light company. The whole cost of energy for opening and

closing the bridge only amounts to 0·83d. at 4d. per unit. The bridge was opened and closed 3,002 times during last year, the total cost of power required being £10 5s. 8d. W. H. S.

1205. *Fulham Electricity Works.* (Electrician, 46. pp. 612–620, Feb. 15, 1901.)—The station is worked on the two-phase alternate current system in conjunction with a dust destructor. It stands on a site which has a river frontage of 370 feet, the total area being 4 acres, though only a small portion of this is occupied by the works at present in existence. The destructors, which are by the Horsfall Company, are placed in two batteries, one at each end of the six boilers, and they occupy with the boilers a space 137 feet long and 87 feet wide. There are at present twelve destructor cells, and there is room for four more; they are capable of destroying 120 tons of refuse in twenty-four hours. The tipping-floor is above the level of the tops of the boilers, and runs from end to end of the building; the roadway leading to the tipping-floor has an incline of 1 in 14. The furnaces of the destructors have each a grate area of 30 square feet, and are fired by means of steam blast, which delivers a mixture of steam and air into the ashpit beneath the grate bars. There are six Babcock and Wilcox boilers, each having a heating surface of 1,284 square feet, and being provided with Vicars stokers; the mechanical stokers are used for firing the boilers in the usual way with coal at times of heavy load. The destructor gases reach a temperature of between 1,800° F. and 2,000° F., and are led to a flue which passes below the ground level, under the boilers, and thence through water-cooled dampers to openings which are arranged behind the bridges of the various boilers. The chimney is 100 feet high, has an internal diameter of 8 feet, and is lined throughout with firebrick. The main steam-ring has a diameter of 9 inches, and there is also an auxiliary ring-main of 3½ inches diameter, which is used for supplying steam to the smaller engines and to the feed-pumps. The exhaust steam from the smaller engines is led to a Royle feed-water heater; the larger engines are worked condensing. The water for boiler-feed is obtained from an artesian well, having a bore of 9½ inches. There is an underground storage-tank, having a capacity of 35,000 gallons, and this is connected both to the well and the town mains. The water, which comes from the chalk, is softened by the Atkins process, which is described at length. The engine-room is 110 feet long and 42 feet wide. The steam-pipes are placed, as far as possible, below the floor level. The three two-phase alternators run at 93·7 r.p.m., being of the flywheel type. The Corliss engines are by Musgrave; the alternators are of the Oerlikon design, and were built by the General Electric Company at Manchester. These generators give 300 kw. each, at a voltage between 2,800 and 3,000, the frequency being 50. There are also three direct-current machines, which are used for exciting the alternators and for supplying light and power in the station itself. They are direct-coupled sets, giving 60 kw. at 460 r.p.m.; the engines were built by Musgrave, and the dynamos by the General Electric Company. There are also three Ferranti rectifiers, capable of supplying 50 arc lamps each, though at present there are only two arc-light circuits, having 43 lamps on each. The condensers are of the ejector type, by Koerting, and give a vacuum at full load of 24 inches of mercury. They are supplied with water from the river. This is drawn from a sump composed of piles on the foreshore; but in order to obtain water at all states of the tide, pipes are run from this sump into the river for a distance of 170 feet, and these terminate in a second sump which is always submerged. In order to clean the pipes

and the intake from the river mud, it is proposed, when necessary, to discharge water from the overhead tank (which is used in connection with the condensing apparatus) through the pipes, and so to effect a clearance. The switchboard is by Ferranti. The two-phase current is distributed at high pressure to five substations, where it is transformed down to a pressure of 200 volts, at which pressure it is distributed to consumers. Current of one phase is distributed along one side of the street, and of the other phase on the opposite side. In the case of motors, a service line will be run across the street, and both phases brought in. The substations each contain two transformers of 50-kw. capacity. The article contains drawings showing the general arrangement of the station, the details of the water-softening plant, and the general design of the Oerlikon generators. In addition to these, there are several process blocks. W. H. S.

1206. *Transmission at* 40,000 *Volts* (*Telluride*). **J. R. Cravath.** (Elect. World and Engineer, 37. p. 307, Feb. 23, 1901.)—The Telluride Power Company of Utah have 105 miles of line completely encircling Lake Utah. The transformers are Y-connected and the neutral points grounded. They are oil insulated. The line insulators are triple-petticoat glass 7 inches in diameter, the wires being tied into a groove on the side. The wires take the corners of an equilateral triangle of 64-inch side; the top wire is on a pin on the top of the pole, the other two are on a 7-foot cross-arm. Telephone wires could not be run on the same pole. The capacity of the 105 miles is such that the apparent volt amperes at the power-house are 750; the ammeter falls as the wattmeter rises. At two-thirds of full load the power-factor is 95 per cent. The 5,000-volt distribution in the town of Provo is by overhead No. 8 B.W.G. iron wires. The pole-lines run down the centre of the streets, the transformers and street lights being hung directly from the cross-arms. M. O'G.

1207. *Wigan Electricity Works.* (Elect. Engin. 27. pp. 150–160, and 164–167, Feb. 1, 1901.)—The station contains four Babcock and Wilcox boilers, each having 3,140 square feet of heating surface, fitted with superheaters and chain grate stokers. The steam-mains are arranged in duplicate, but are not connected in a ring. An elaborate system of coa -conveyors is installed, the arrangements of which are fully described and illustrated by drawings. Water-softening plant, worked on the Archbutt-Deeley system, is used; the water is said to be reduced from 12 degrees of hardness to 4 degrees at a cost for chemicals of ½d. per 1,000 gallons. There is also an economiser, consisting of 512 tubes, the whole being divisible by valves into three independent sections. The engine-room contains four steam dynamos. The two larger sets give 420 amperes at any voltage from 460 to 500 when used on a lighting load, and 300 amperes at any voltage between 500 and 550 when used on a traction load, the speed being 350 r.p.m. The smaller sets are about two-thirds of the size of the larger ones. Koerting ejector condensers are used; those for the larger engines require 22,000 gallons of water per hour, the vacuum obtainable being equal to 24 inches of mercury. The dynamos are run as shunt-wound machines when supplying the lighting-circuits, and as compound-wound when supplying energy to the tramways. There is a battery of E.P.S. accumulators, consisting of 280 cells, each cell containing 15 plates; they are capable of discharging at the rate of 75 amperes for ten hours, or 300 amperes for one hour, the e.m.f. falling to 1·87. The battery is charged by putting the cells across the bus-bars, the

number being then reduced until charging takes place. The cells so cut out are charged independently by a small motor-driven dynamo. There are seven balancing machines in all on the lighting system, distribution being effected by the three-wire method; two of these balancers are in the station, and the remaining five are in substations in different parts of the town. Boosters are used for increasing the pressure, at times of heavy load, on those feeders which run to distant parts of the town. For the lighting circuits three concentric feeders are run, each conductor containing ½ square inch of copper; the distributors are triple-concentric, the outers having a sectional area of 0·2 square inch. There are also three tramway feeders, each of 0·3 square inch of sectional area.

The article concludes with a brief description of the tramway work. It also contains several drawings, showing the arrangement of various parts of the power station. W. H. S.

1208. *Accumulator Traction on the Bologna-San Felice Railway.* **Lanino.** (Elettricità, Milan, 20. pp. 6–10, Jan. 5, 1901. Paper read before the A.E.I. at Geneva.)—The Bologna-San Felice line is 42½ kilometres in length, with thirteen intermediate stations; the traffic is very small, consisting on the average of 180 passengers daily, and 40 despatches and consignments of goods. The Società delle Strade Ferrate Meridionali has replaced the ordinary steam service with a service of accumulator cars, by way of an experiment, to ascertain whether electric traction is suitable for a line with restricted traffic. The line has few curves, but many gradients up to 6 %. The cars, by Fratelli Diatto, of Turin, are bogie motor cars, 17·5 metres in length, divided into two classes, seating together 52 passengers, with a central space to contain 2 tons of goods; at each end is a cabin for the driver. A four-pole motor, by Ganz & Co., is mounted on one axle of each truck; each motor weighs 1,800 kilos, complete with gear and suspension, and can exert a tractive effort of 400 kilos at the rim of the 102 cm. wheels, when running at 750 r.p.m. The accumulators are of the Pescetto type, by the Società Cruto, in which the positive plates are covered by a thin sheet of perforated lead. Each shell has eight positive plates, 146 × 210 mm., guaranteed to have a capacity of 9 ampere-hours per kilo, at a normal rate of 4·5 amperes, the maximum discharge being 20 amperes per kilo. The cell-box is of ebonite, and weighs, complete with acid, 21 kilos. Twenty-four cells are contained in a wooden box with external iron frame, lined on the bottom with lead, and on the sides with glass.

Each car contains twelve of these boxes, four, however, being somewhat larger to contain each ten cells for lighting. The capacity of the whole battery is 300 ampere-hours, or 180 kw.-hours at 600 volts. The cells are joined up to a switchboard in the goods van, and are arranged in three batteries, which can be put in series or in parallel by one of the two controller cylinders; the second controller cylinder is an ordinary series-parallel controller for the two motors. There are in all eight different running positions—four with the batteries in series and four in parallel. For ordinary service a Westinghouse compressed air-brake is used, supplied by a motor pump, automatically controlled by a switch, which is opened and closed by the air pressure. In reserve are a hand-brake and the usual electric brake, applied by short-circuiting the motors through a resistance.

Power is taken from the three-phase network of the Società Co-operativa di Elettricità di Bologna, at a pressure of 3,000 volts. Two 80-h.p. three-phase induction motors, by Ganz, take current at this pressure, and drive

directly, at 840 r.p.m., two six-pole continuous current machines, also by Ganz, giving a voltage variable between 550 and 750 volts. The batteries are charged in the cars, and each charge takes 2 h. 40 m. One charge is amply sufficient for a go and return journey. The single journey occupies 1 h. 20 m., and a car starts every three hours. Two cars only are in use together, one on the line, while the other is charging ; two other cars are kept in reserve. The following are figures relating to the power taken in normal running, which, however, have been obtained under favourable conditions of weather. At starting, the current taken by the motors in series, while the batteries are in parallel, is 300 amperes. In running at the normal speed of 45 km. per hour with motors and batteries in series, the current varies from 60 to 80 amperes. The consumption per return journey is 120 units, or three watt-hours per ton-kilometre. The total efficiency from the dynamo to the car axles is about 50 per cent. From the motor characteristics it has been calculated that the traction coefficient in running varies from 2·8 to 4·5 kilos per ton, and in starting from 6 to 8 kilos. G. H. B.

1209. *Jacques Cartier Transmission Plant.* (Canad. Elect. News, 10. pp. 1–4, Jan., 1901.)—The station which transmits power to Quebec obtains power from the Jacques Cartier River at the rapids of St. Gabriel, 17 miles from Quebec. The river being divided by an island, two dams were built, one 142 feet and the other 158 feet in length. These raise the level of the river sufficiently to give a level surface for six miles up. At one end of the main dam is a masonry bulkhead, from which two pipes, 13 feet in diameter, lead to the power-house, distant 270 feet. The turbines are driven under a pressure of 17 feet, with a suction-tube of 15 feet.

The power-house contains two 54 in. McCormick turbines of 1,710 h.p. at 150 r.p.m. ; and two 18-in. turbines, running at 350 r.p.m. for the exciters. The large turbines have governors of the Lombard type, which, however, cannot be used owing to the inertia of the water in the long-feed tubes. The exciter turbines have Walsh governors. Two Westinghouse three-phase generators are driven directly by the turbines, and give 750 kw. at 2,000 volts and 60 $\sim$. The exciters, also direct connected, are 37·5 kw. 125 volt four-pole machines. There are two sets of step-up transformers, each of three 250-kw. units, of the Westinghouse self-cooling oil-insulated type, raising the voltage from 2,000 to 20,000 volts ; these are delta connected on primary and secondary.

Just outside the city is a transformer substation, with two sets of step-down transformers, each consisting of two 375-kw. units with Scott connection for transforming the 20,000 volt three-phase current to two-phase current at 2,000 volts. A mile distant is the distributing switchboard, provided with Stillwell regulators, boosting 4 per cent. each way.

The transmission line consists of two sets of three No. 4 B & S hard-drawn copper wires, carried on 35-feet poles. Each set is transposed five times, and the telephone line at every second pole. Wurt's lightning arresters are placed at each end. The city is divided into eight districts, each fed by one or more banks of transformers, on a three-wire system, with 108 volts on each side. An entirely separate system supplies current for power at 500 volts. G. H. B.

1210. *Chicago Electricity Works (Commonwealth Electric Company).* (West. Electn. 28. pp. 29–33, Jan. 12, 1901.)—The polyphase plant outlined in Abstract No. 2327 (1900) is described in detail. The district to be supplied is

over 60 square miles in area. The station is built of brick, and at present contains four Babcock boilers of 500 h.p. each, with chain-grate stokers and superheaters. The coal and ash are handled by conveyors, driven by two three-phase G. E. motors of 30 and 20 h.p., and capable of handling 50 tons per hour. The chimney is 200 feet high, chiefly of steel. The two engines are vertical cross-compound, built by the Southwark Foundry and Machine Company. One has cylinders 15 and 32 inches × 36 inches stroke, the other 23 and 52 inches × 36 inches, and both run at 150 r.p.m. The alternators are of 400 and 1,000 kw. output, by the General Electric Company, with 48-pole revolving fields, and generate three-phase current at 4,150 volts, 60 cycles per second. A special electric governor, controlled from the switchboard when synchronising or dividing the load, is fitted to each engine.

Jet condensers are used, in conjunction with two Worthington cooling towers, working by natural draught. There are three 30-kw. exciters, which also provide power for an electric travelling crane and for charging automobiles.

In order to utilise the existing overhead single-phase feeders, these are connected between the neutral point of the Y-connected armatures of the alternators, and one or other of the three outer terminals, at 2,400 volts, balancing the load as well as possible.

Three-phase feeders at 4,150 volts are led direct to the substations, and to a three-phase motor and lighting system which is being developed. Special care has been taken to render the switchboard absolutely safe to handle. All cables inside the building are paper-insulated and lead-covered. The main transmission line to the present substation is three miles long, and consists of eight No. 2 copper conductors, carried by glass insulators on cedar poles 50 feet long. The substation contains switch gear for eight two-wire single-phase and two four-wire three-phase feeders, without step-down transformers. The distributing feeders are all three-core, paper-insulated and lead-covered, while all distributing cables are single. Provision has been made for adding two 500-h.p. boilers, and two 1,000-kw. generating sets at the power station, which can also be extended to receive six more boilers and four more 1,000-kw. sets. A distributing substation will be erected in South Chicago, nine miles from the power station, in the near future. Numerous illustrations accompany the article. A. H. A.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1211. *Measurement of Tramway Currents in Waterpipes.* **S. Krohn.** (Elektrotechn. Zeitschr. 22. pp. 269–271, March 28, 1901.)—The author was instructed by the Union Electricity Company to examine into the state of affairs in a certain town where it was known that corrosion was taking place, and, if possible, to suggest a remedy. His method of examination was as follows. There was a small truck on which was mounted a cable drum, the latter carrying two cables about 300 yards long, having sectional areas respectively of 4 and 14 square mm. The method of measurement may be explained by the aid of the accompanying diagram. R_1 and R_2 are two gas or water pipes, leading to houses about 250 yards apart: these pipes are connected, as shown, to the main, the currents in which have to be measured. The above-mentioned cables K and K_1 are connected through a voltmeter

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

and ammeter respectively to the pipes R_1 and R_2. When the switch C is open, let the voltmeter reading be V: when the switch is closed, let voltmeter reading be V_1, and ammeter reading be i: then the current flowing in the main gas-pipe is $= i\frac{V}{V - V_1}$, and the resistance of the length of piping is $= \frac{V - V_1}{i}$.

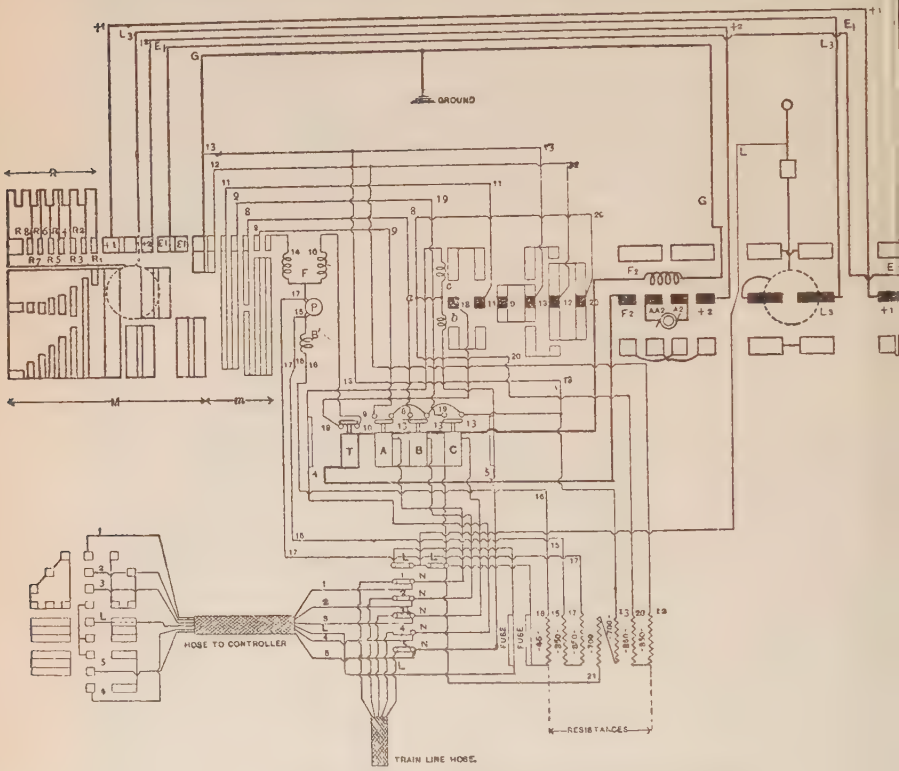
The author describes more particularly the connections which existed between the gas-pipes, rails, and switchboard on the system which he examined, and as the result of alterations made, the current flowing in the gas-pipes was reduced from 30 amperes to 44 milliamperes. Obviously owing to the varying currents, V, V_1, and i can only be read as the mean of a large number of readings, taken at stated intervals, say, of five seconds. Diagrams are given

showing the way in which the readings varied. Thus, though the mean value of the current in the gas-pipes was reduced to 44 milliamperes, it rose momentarily as high as 88, and fell as low as 12.

Finally the author considers the conditions which may reasonably be imposed on a tramway company with a view to the prevention of electrolysis. He objects entirely to the English system of imposing a definite fall of voltage in the rails. He points out that the earth currents depend not only on the fall in volts, but also on the nature and condition of the soil. If a definite fall of volts produces a condition of safety in ground that is habitually wet or marshy, it is unnecessarily high for ground that is sandy or rocky, and therefore may impose very unnecessary expense on the tramway company. The want of elasticity in such a condition is considered a defect, inasmuch as it cannot reasonably be applied to all kinds of tramways, both urban and rural. He suggests as an alternative that when the line is in working order, the currents in gas and water pipes should be measured, and at no time should a pipe of 3 cm. diameter carry more than 1 ampere, and so on in proportion. If this or some similar limit were exceeded, the tramway company should be called on to rectify the defect. W. H. S.

1212. *Sprague Multiple-unit System.* **E. Chilton.** (Amer. Electn. 13. pp. 39–41, Jan., 1901.)—The chief practical consideration in designing any multiple-unit system is that the working current be delivered directly to the car that utilises it. Fig. 2 is the car-wiring diagram for the Sprague multiple-unit system. Heavy lines represent main motor circuits; light lines represent control circuits. M is the main controller drum, *m* the control-circuit part of the main drum, which part is electrically separate from the main motor circuits. P is the armature of the pilot motor which drives the main controller, and which has two field coils, F_{10}, F_{14}, arranged for securing either direction of rotation so as to turn main controller "on" or "off." B′ is a coil in series with pilot motor, arranged to hold off a spring brake when current is passing through motor. The reverser is a drum operated by two solenoids at either end of a band which passes over it: unless current is passing

through one of the solenoids a strong spring brings the drum into the central "off" position. T is a device called the "throttle," which makes it impossible to accelerate above a predetermined rate: if the main current rises too high, the throttle opens the pilot-motor circuit and stops the main



CAR WIRING DIAGRAM OF THE SPRAGUE MULTIPLE-UNIT SYSTEM.

controller. A, B, C are "relays" which are used to run the main controller respectively to "off" position, last series notch, and last parallel notch. The master controller controls the pilot motor and reverser coils. [See further Abstract No. 395 (1900).] E. H. C.-H.

1213. *Accumulator Tramway Traction.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 116–127. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 61–81 and 177–181.)—Replies are given by various tramway companies as to the cost of accumulator traction. The report which was presented by **Krüger** in 1898 on the working of the mixed system at Hanover is reprinted. Particulars are also given by **E. E. R. Tratman**, of the accumulator line at Chicago, where the mean cost per car mile in 1898 was 43·75 centimes.

In the report by **Broca** and **Johannet** the whole matter is impartially considered from various points of view, and it is concluded that where the trolley is prohibited, accumulators may sometimes be used to advantage, and that under exceptional conditions they may be even cheaper than the trolley. Success depends upon—(1) centralisation of the batteries, (2) manufacture of

strong plates by the tramway company itself, (3) slow charging, (4) suitable placing of the battery on the car, and convenient handling, (5) suitable disposition of terminus and depôts. At St. Denis and Asnières the cost of making plates does not exceed 10 centimes per kg. of lead.

Discussion.—**Boulvin** was of opinion that accumulator traction was generally impracticable, because, in order to avoid breakdown, such a large factor of safety was necessary to meet the exceptional circumstances that must be provided for. The speaker discussed many objections. **Micke** (Berlin) gave some account of the failures of accumulator traction at Berlin, and was strongly opposed to the system. **Krüger** (Hanover) said that tenders were now being adopted for the accumulators at Hanover with good results; in that way the batteries are employed only on those lines where they are required, and inconvenience from acid fumes is avoided. Rapid charging, which is injurious, is avoided. The maintenance and renewals cost only 2 pfennigs in excess of the price of the raw lead per kg. In terms of the car km. this amounts to 0·5–0·6 pfennig per "mixed" car km. (*i.e.*, over that part of the route where the battery is being charged, not over the whole route), or 1·25–1·6 pf. per accumulator car km., including maintenance of all accessories. The generating costs at Hanover in 1899 were 6 pf. per unit; this fell to 5 pf. last year, and to 4·8 pf. last July. The consumption per ton km. is 50 watt-hours. **Koehler** (Berlin) said that the Grande Société de Tramways de Berlin had found the cost of maintenance to be about ten times the figure given by Krüger.

The Congress adopted a resolution to the effect that no important advance had been made in accumulator traction, and that this system should be adopted only in special cases. W. R. C.

1214. *Heating of Tramcars.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 128–131. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 82–86 and 183–192, and 4 plates.)—Report by **C. de Burlet** (Brussels Tramways) on replies received to a question on this subject.

(1) *Heating by Stoves and Movable Appliances.*—This system is the cheapest in first cost and in maintenance, but has many inconveniences. The cost of a stove is about fr. 35, and the cost of fuel is fr. 0·25 per 15 hours. Hot-water receptacles are more costly.

(2) *Heating by Hot Air.*—The Northern Railway of Milan employs a stove supplying a system of pipes with hot air; the first cost is fr. 350 per car, and the running expenses are fr. 0·05 per car-kilometre. The Utrecht tramways employ four gas-stoves per car, consuming 320 litres of gas per hour, and raising the temperature of the car 13° C.

(3) *Heating by Steam or Hot Water.*—The Compagnie Générale des Chemins de Fer Vicinaux Français heat the cars by hot-water circulation; the prime cost is fr. 314 per car, and the running expenses fr. 0·334 per car-day, burning wood charcoal at fr. 51 per ton; the rise of temperature is 24° C. This system gives good and economical results, but has the disadvantage that the water is liable to freeze when the apparatus is not in use.

(4) *Electric Heating.*—The cost of current for the heaters is very heavy. At Hanover it amounts to fr. 2 for 16 hours, the first cost being 40 marks. The Société Nationale des Chemins de Fer Vicinaux employs heaters taking 7 amperes, at a cost of fr. 0·18 per tram-hour of two cars. The Union Elektricitäts Gesellschaft are endeavouring to utilise the heat lost in the

starting and regulating resistances for heating the cars, having two sets of resistances—one in the car for winter use, and one outside for summer.

Discussion on Report.—**Monmerqué** stated that the Compagnie Générale des Omnibus in Paris employs heaters with specially prepared briquettes costing fr. 200 per ton ; the cost is about fr. 1·00 per car per day. **Von Siber** describes the electric heating of the Bielitz-Biala tramcars, the heaters taking 4 to 5 amperes. **Blondin** considered it sufficient to provide foot-warmers, which was done in Paris at a cost of fr. 0·71. G. H. B.

1215. *Falk Rail-Joint.* (Union Int. Permanente de Tramways : Questionnaire, 1900, pp. 110–115. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 56–60, and 171–175.)—Only two tramway companies replied to the questions addressed to them on the subject of the Falk, or cast, rail-joint, namely, the Grosse Berliner Strassenbahn Gesellschaft, and the Compagnie Générale Française de Tramways of Paris. The Tramways Bruxellois gave the replies received by them from various American and French companies to whom they had addressed a similar question.

Report by **Fischer-Dick** (Berlin Tramways) on the replies received.

In America, the Falk joint has been adopted by the Citizen Railway Company over a length of line of 40 kilometres, and by the Memphis Street Railway Company over a similar length of line ; the Chicago City Railway Company has cast 40,000 joints, and the Twin Rapid Transit Company 24,000 joints. In France, there are in Lyons 1,700 Falk joints, in Rouen 1,200, in Havre 6,500, in Marseilles 6,000, in Nice 3,400, and in Paris 2,600. In Berlin, the Tramway Company has cast 7,609 joints. The cost of the joint to the different companies is as follows : At Havre, fr. 20·30 (or, without allowing for royalties and amortisation, fr. 15·60) ; at Lyons, fr. 20·10 ; at Marseilles, fr. 16·50 ; at Paris, fr. 19·89, exclusive of royalties ; at Berlin, the price paid to a contractor was 20 marks, or, including paving, 25 marks ; the cost to the Twin Rapid Transit Company is 2 dollars for 30 kilo rails, exclusive of paving and royalties. The plant, material, and labour required are as follows : At Lyons, 25 moulds and accessories, costing fr. 2,075, exclusive of the furnace ; at Havre, 30 moulds and 60 dogs were sufficient for making 100 joints in a night, the cost of material and plant being fr. 18,500 ; at Marseilles, the cost of 60 moulds and accessories was fr. 17,000 ; the Chicago City Railway Company cast in a night 150 joints for 4½ metre rails, 90 joints for 7 m. rails, and 85 joints for 9 m. rails ; for this was required one furnace, two workshop cars, 6 horses, and 35 men ; inclusive of opening and repaving the track, the time taken was a day and a half ; the Twin Rapid Transit Company employs 50 men to make 75 to 100 joints in a day, including laying the rails ; the Citizen Railway Company states that 65 kilos of metal are required for cast blocks 6 inches long, and 70 kilos for blocks 7 inches long ; the Berlin Tramways state that, allowing 75 kilos per joint the cost of metal is 400 marks for 50 joints. The breakages of joints are found to be : by the Citizen Railway Company, 1 per cent. ; by the Chicago City Company, ¼ of 1 per cent. ; by the Twin Rapid Transit Company, in asphalt, none, in macadam and pavement, 5 per cent. ; by the Memphis Street Railway Company, ½ of 1 per cent. ; at Lyons, ½ of 1 per cent. ; at Havre, 4 in 3,800 joints ; at Marseilles, 0·4 of 1 per cent. ; at Paris, 2 in 2,600 joints ; at Berlin, 1¼ per cent. Breakages are attributed to want of care in cutting the rail ends ; cracks form either directly on cooling or during frost. The Twin Rapid Transit Company lays an ordinary fishplate joint every 1,000 feet ; the Compagnie Générale Française, every 250 metres ; at Berlin

the rails are continuous. After the application of the Falk joint, the rails contract considerably; at Berlin, the contraction is 35 to 50 mm. per 100 m. of rail. So great is the force of contraction that no expansion has ever been observed under the hottest sun. The electrical resistance offered by the joint depends largely on the care used in fitting the rail ends; there is, however, no need for bonding the joints. The Falk joint has an advantage over the electrically welded joint, in that it does not heat the rail ends to so high a temperature, and maintains the quality of the metal. All the companies using the joint are unanimous in declaring its superiority over the fishplate joint. G. H. B.

1216. *Tramway Brakes.* (Union Int. Permanente de Tramways: Questionnaire, 1900, p. 138. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 94–104.)—Only four companies replied to the question addressed to them on the subject of brakes, and the information supplied was insufficient to form the basis of a report. The reporter, **Monmerqué,** confines himself therefore to giving particulars of the regulations issued by the Paris authorities, and of the brakes employed by the Compagnie Générale des Omnibus. The regulations decreed by the President of the Republic impose the following conditions. Locomotives must be provided with hand-brakes. The brakes must be sufficiently powerful to stop the locomotive when running at a speed of 20 kilometres per hour on the level on clean and dry rails, in a distance of 20 metres. Every car must also be provided with brakes, which, together with the locomotive brakes, must be sufficiently powerful to stop the whole train in a distance of 20 metres under the same conditions. The Paris Police in July, 1900, increased the severity of these conditions by imposing them on a down gradient of 2 per cent. instead of on the level, and by stipulating that every car have two independent brakes acting on all the axles. The Compagnie Générale des Omnibus employs the following brakes on each motor car: (1) a direct-acting compressed air brake, applicable by the driver; (2) an automatic compressed air brake applicable by driver and conductor; (3) a hand-brake applicable by driver and conductor; (4) a brake applicable by the driver by short-circuiting the motors.

Discussion.—**Von Leber** deprecated the multiplication of brakes, as giving the driver too much to do on an emergency. At Vienna a chain hand-brake is used, provided with a reserve chain, and an electrical short-circuiting brake. **Fromm** gives the results of an investigation made by him on the brakes employed by sixty-three different tramway companies. Thirty-five companies employ the short-circuit brake, eighteen companies electromagnetic brakes, and six employ compressed air brakes; the majority have besides hand-brakes. At Hamburg the following results were obtained: a car with one motor and Union electromagnetic brakes on the motor axle, attached to a trailer with similar brakes, stopped on dry rails in 10–12 metres, on sanded rails in $9\frac{1}{2}$–$11\frac{1}{2}$ metres, and on wet rails in 19–26 metres; the cars were running at 22 km. per hour on the level. A motor car with two motors and short-circuit brakes, attached to two trailers, with Union and Schuckert electromagnetic brakes respectively, running under the same conditions, stopped on dry rails in $8\frac{1}{2}$–14 metres, on sanded rails in $5\frac{1}{2}$–12 metres, and on wet rails in 21–38 metres. The same train, but with Schiemann rail-brakes, instead of the short-circuit brake, on the motor car, stopped on dry rails in $6\frac{3}{4}$–10 metres, on sanded rails in $4\frac{1}{2}$–6 metres, and on wet rails in 14–$20\frac{1}{2}$ metres. The investigations led to

the following conclusions. (1) Short-circuit brakes give good results, except when they are used on the ordinary service brake. (2) Electromagnetic brakes are to be recommended for heavy cars or on lines with heavy gradients. (3) Compressed air brakes give good results, but their use is too restricted to enable general conclusions to be formed. **Koehler** (Berlin Tramways) spoke on the Sperry electromagnetic brake employed by his company. The braking is found to be rather too sudden, and the motors are kept more continuously at work. G. H. B.

1217. *Central Station Equipment for Tramways.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 31–93. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 45–49 and 151–158.)—Report of **Thonet** and **d'Hoop** on the sixteen replies received from various companies to a question put by the Society on the above subject. *Capacity of station.*—The replies refer to stations varying in capacity from 200 kw. to 5,000 kw. at Marseilles; or 13,500 kw. in the three Berlin stations. The capacity is in general double the maximum output demanded. The average power required on days of maximum traffic is about one-third greater than, and on some tramways double, that in normal conditions of traffic. The ratio of the mean to the maximum output is generally from 1 : 1·5 to 1 : 1·7, rarely 1 : 2. *Dynamos* are always direct driven, except in the case of machines of less than 100 kw. They are generally compound-wound, but sometimes shunt-wound, in view of a possible installation of accumulators. They are capable of withstanding an overcharge of 25 per cent. for 1½ hours, and sometimes of 40 per cent. for one hour, with a rise of temperature of not more than 60° C. Seven companies of the sixteen employ accumulators. *Steam engines* are generally compound, except in France, where many single-cylinder Farcot engines are in use up to a power of 1,000 h.p. The valve-gears used are Corliss and Rider. The speed varies in France from 65 to 120 r.p.m., and in Belgium and Germany from 90 to 150 r.p.m. The engines are generally horizontal, using jet condensers, except in Germany and in certain stations where want of room has dictated the use of vertical engines and surface condensers. The pressure used is for compound engines from 8 to 10 kilos per sq. cm., and for single-cylinder engines from 6 to 7·5 kilos. *Boilers.*—The boilers in general use are, in Germany, Gehre, Steinmüller, Cornwall, and Babcock and Wilcox; in France and Belgium, Piedbœuf, Babcock and Willcox, and Denayer. The heating surface varies from 150 to 250 sq. metres, and the grate surface from 2·5 to 6·0 sq. metres. In general, one quarter of the total number of boilers are in reserve. The Compagnie Générale Française des Tramways à Nancy employ in their boilers the "Émulseur Dubian," an arrangement designed to promote circulation of the water. Tests have shown an economy of from 15 per cent. to 50 per cent. resulting from its use.

The Orleans Tramway Company employ Crossley gas engines of 165 h.p. each, with Fichet and Heurtey plant for producer gas. A battery of accumulators is installed with booster for charging. The mean consumption of fuel during a year is 750 grammes of anthracite per kw.-hour, or 450 grammes per car-kilometre, corresponding to 600 grammes per b.h.p.-hour. *Mechanical stokers* are in use only at Havre, where the Godillot type is installed. Boilers are cleaned generally every two or three months. Only a few companies employ *smoke-consumers;* at Marseilles, smoke-consumers by the Société Alsacienne of Mulhouse are in use, and give satisfactory results. *Stacks* have in general a height of over 40 metres, with a diameter of about 3 metres at the

base and 2 at the top. *Feed-water heaters.*—In the majority of cases the feed-water is heated only by the exhaust from the feed-pumps, which produces a rise of temperature of about 45° C. Only one installation uses the exhaust from the main engines for this purpose instead of condensing it. In three installations, at Havre, Marseilles, and Nancy, Green's economisers are used. *Superheaters* are employed by four companies in nine stations; in each case the superheaters are in the boilers, the superheat varying from 40° to 115° C. Only in one case was an estimate given of the economy resulting from their use, the figure given being 3 per cent. *Apparatus for cooling the condenser water* are employed in most stations; they consist either of cooling towers or, more especially in France, spray-coolers. *Feed-water purifiers* are used at Havre and Marseilles only. The Société Nationale des Chemins de Fer Vicinaux inject petroleum to prevent incrustation. *Consumption of fuel in evaporation.*—The best results, taking into account the calorific value of the fuel, are obtained with fire-tube boilers. *Consumption of steam* varies from 5·7 to 8·7 kilos per i.h.p., putting aside the single case in which condensers are not employed. The installations making use of superheaters show the highest consumptions. The engines with Corliss gear give better results than slide-valve engines. At Havre and Nancy, with single-cylinder machines, the consumption is only 6·25 and 6·90 kilos per i.h.p. *Consumption of oil.*—The figures given relative to the consumption of oil differ enormously; they vary from 1 to 8 for cylinders and from 1 to 20 for bearings. At Brussels the oil is extracted from dirty waste by a centrifugal machine, with very economical results.

The author concludes with the following recommendations :—

In large stations the engines should be compound-condensing and direct-driving.

In medium-sized installations it is generally of advantage to employ buffer batteries.

In small stations the use of gas engines and Dowson gas gives very good results.

Discussion on the report.—**Monmerqué** proposed to modify Thouet and Hoop's first recommendation by adding the alternative of triple-expansion engines, on the ground of their economy and of the better regulation they give. **Baumgardt** recommends the use of buffer batteries, even in the case of large installations. **Thonet,** in reply, did not agree that any economy resulted from the use of batteries in large installations; their chief advantage is in equalising the load on the generators, and in large installations the variations of load are less than in small ones. He agreed to Monmerqué's addition.

The conclusions of the report were agreed to by the Congress. G. H. B.

1218. *Acceleration of Electric Cars.* **G. H. Morse.** (Street Railway Journ. 17. pp. 131–133, Feb., 1901.)—The problem of the best acceleration to use in starting cars is one of pressing importance. If the stations be far apart and the speed moderate, it will be economical to employ motors having little reserve capacity, and to use very little regulating resistance for starting the cars. When stops are frequent and high speed is necessary the conditions of economy are entirely different. We may use more powerful motors, but a limit is soon reached, as the acceleration only increases very slowly with the size of the motors. The best means to accomplish a rapid start is to keep the acceleration constant until the required speed is reached. In order to do this we must use large regulating resistances and gradually cut them out as the currents fall below their maximum safe values. In this case the velocity

curve is practically a straight line through the origin, which finally bends with rather a sharp curve as the maximum speed is approached. The author gives a graphical solution of the problem of finding the various combinations of the commercial motors to be employed on a given electric car so that its actual velocity at any instant may agree very closely with any desired velocity curve. The final result shows whether the proposed set of motors is suitable, and it gives the required controlling resistances and the efficiency of the various combinations at each stage of the start when the car accelerates according to a definite economic law. The author finds that practical velocity curves can be closely imitated by a parabola, or for very high speeds by a straight line the end of which is capped off with a parabola. A concrete case is worked out. A train weighing 132 tons is to start with a given acceleration curve on an incline of 0·5 per cent. so that it gets up a speed of 24 miles in 30 seconds. The type of motor considered is the G.E. 2,000, and curves are drawn showing the kilowatts absorbed by this motor from the line at 500 and at 250 volts for given horizontal efforts. By combining the various curves the author shows how to calculate the controlling resistances required at each instant during the start. A. R.

1219. *Automatic Electric Block-signals for Railways.* **L. Kohlfürst.** (Elektrotechn. Zeitschr. 21. pp. 929–932; 950–952; 980–982; 998–1001; and 1017–1019, 1900.)—In these articles, the most important systems of automatic electric block-signalling are fully described. The first given is that of Joseph Sacek, which is designed to work with steam locomotives. On the locomotive is mounted a small dynamo or an accumulator, one terminal of which is earthed and the other is connected directly to a brush on one side of the locomotive, and also through the coils of a Hughes electromagnet to a brush on the other side of the locomotive, this electromagnet being adapted to actuate either a steam whistle or a brake-releasing device. The passage of the train over the rails completes local battery circuits including relays, which block the line for two sections of line in the rear, so that a following train fitted with the apparatus above-mentioned will be warned that the line is not clear. A system of mercury contacts acting by the compression of air in a closed vessel under the rails on the passage of a train is also described for use in connection with this system.

The Timmis-Lavezzari system is then described, for a description of which see Abstract No. 1738 (1900).

Ceradini's system is next described. This system comprises blocking signals on both the line and locomotive. The signals on the locomotive consists of two Lartigue steam whistles, one of which is sounded by an electromagnetically operated valve when the train enters a block-section, and the other is similarly sounded if the section is clear, this being effected by a battery on the train and fixed contacts on the track. The line is divided up into sections, in each of which is an instrument comprising two electromagnets. These electromagnets oscillate a balance-beam whereby a signal disc is rotated and contacts are made or broken, controlling the sounding of the "line clear" whistle on the locomotive.

The Krizik system is also described, for which see Abstract No. 2091 (1900).

The Siemens and Halske partly automatic system comprises an electromagnetically controlled pawl whereby the signal is held in the "line clear" position against the action of gravity, this pawl being tripped by the action of a current in a circuit completed by the passage of a train over the section, so

as to allow the signal to move into the "danger" position. The signal is returned to the "line clear" position by hand.

Basanta's system, in addition to giving audible signals, permits telephonic communication between the carriages, and between the train and the stations.

The danger signals are given exclusively on the locomotive on which is arranged an alternate-current dynamo giving from 10 to 40 volts. From station to station insulated conductors, l, are arranged parallel to the rails; these conductors do not, however, meet, but are overlapped by separated insulated conductors, l_2, at the stations, whilst two short sections of insulated conductor, l_1, are arranged respectively about 500 metres in front of and behind each of the points, *e.g.*, of the station-loop of a single line railway. The locomotive bears three brushes, each adapted to engage respectively with one of these series of conductors, the locomotive itself and the rails serving as a common return. The locomotive is also provided with a telephone set, a magneto-machine, and two alarms, each giving notes of distinct character and earthed through the dynamo; the stations are fitted with one alarm, switches, a telephone set, and two rheostats; and the sections l_1 to an alarm operated by clockwork and provided with an electromagnetic release. One of the alarms on the locomotive serves as the "danger" signal, and is operated by depressing keys either at the stations or in the signal-boxes, these keys putting the conductors l_2 to earth. By earthing l, the other alarm on the locomotive is rung, after which telephonic communication can be opened with the train, whilst the clockwork alarm is released when the locomotive passes each section l, and rings for five minutes. The train can always ring up the stations by means of the magneto, whereupon the telephone can be switched into circuit. C. K. F.

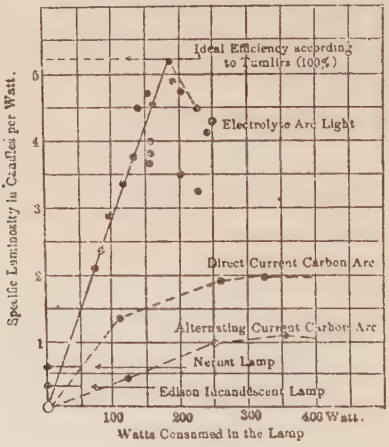
1220. *Electric Automobiles.* **E. A. Sperry.** (Elect. Rev. N.Y. 36. p. 596 and pp. 608–610, 1900. Paper read before the National Electric Light Association, May 24, 1900.)—Recent tests showed that for two batteries of the same capacity on the same carriage, and having a life of 3,000 to 4,000 ton-miles, a Planté battery ran 20 miles per charge, weighed 1,260 lbs., gave 5·25 watt-hours per lb. and required 21 lbs. of cell per ton-mile; a Faure battery ran 29 miles per charge, weighed 980 lbs., gave 6·5 watt-hours per lb., and required 30 lbs. of cell per ton-mile. The remarkable advantage of halving the weight of batteries for the same cost and output is pointed out. M. O'G.

ELECTRIC LAMPS AND LIGHTING.

1221. *Artificial Light of the Character of Daylight.* **A. Dufton** and **W. M. Gardner.** (Brit. Assoc. Report, 1900, pp. 631–632.)—Starting with the electric arc light as being nearest daylight in character, the authors have attempted to imitate by direct absorption the effect produced by scattering in the atmosphere. The light of an arc lamp consists of two distinct parts: (1) The light from the glowing carbons; (2) the light of the arc itself, characterised by its richness in violet rays. In lamps of the enclosed arc type the length of arc is increased, and consequently such lamps give a light richer in violet rays. Although arc lights vary somewhat in the proportion of violet light, they all agree in being richer than daylight in the amount of red, orange, and yellow rays, compared with the amount of green and blue. Owing to the peculiar transparency of colours to red lights already known, it

is of primary importance that the proportion of red light should be carefully adjusted. Small variations in the amount of violet light are of minor importance, owing to the eye being less sensitive to such rays, and also because in mixing colours there is not the same tendency to develop a band of violet as occurs in the red, since yellow colours generally have complete absorption in the violet. The required absorption of the less refrangible rays can be effected by means of blue cupric salts. A solution of copper sulphate shows strong absorption at the extreme red of the spectrum, the absorption extending with diminishing intensity into the green. For practical purposes the light from the arc is modified by passage through pale blue glass coloured by means of copper. This coloured glass may conveniently take the form of a globe replacing the ordinary globe of the arc light. E. E. F.

1222. *A New Form of Arc Light.* **E. Rasch.** (Elektrotechn. Zeitschr. **22.** pp. 155–157, Feb. 14, 1901.)—This article deals with an invention which is embodied in the German patent No. 117214 of March 18, 1899. Electrodes are made of magnesia, lime, thoria, zirconia, or other refractory substance,



and the light given out by the arc which passes between these electrodes is said to be produced more economically than is the case with the light of the ordinary arc lamp. The electrodes require to be heated before the light can be produced, and this heating is effected by a subsidiary arc, which passes between two good conductors. No details of the mechanism are given. The light emitted by magnesia or zirconia electrodes is brilliantly white, as compared with the violet light of the ordinary carbon arc, while electrodes of fluorspar, chromic oxide, and nickel oxide give a distinctly yellow light. The author distinguishes between "soft" and "hard" electrodes. Under the former head are included substances which have a low conductivity without preliminary heating and can be made to conduct by the application of a sufficient voltage. They make bad electrodes for the purposes of the arc, seeing that ellipsoidal molten "drops" are formed at the tips, and it is impossible without complications to maintain a steady arc. Moreover, with soft electrodes, the voltage does not sensibly increase with the length of arc, and the author states that in order to form a stable and economical arc, it is necessary that this increase should be very marked. "Hard" electrodes are

therefore much to be preferred ; they require considerable heating in order to render them conductors. Photometric tests show that the electrolytic arc light is more economical than anything hitherto known. The author claims that with electrodes of 2·5 mm. diameter, a light of 600 hefner candles can be produced with a consumption of 158 watts, though even this is not the most favourable case quoted. The annexed diagram gives comparative curves, showing the relation between watts and candle-power in the various kinds of lamps. In the ordinary incandescent lamp, the consumption varies from 3 to 4 watts per c.p. ; in the Nernst lamp, from 1·5 to 1·6 watts per c.p. ; in the alternate current carbon arc lamp, 0·8 watts per c.p. ; in the direct current arc lamp, 0·5 watts per c.p. ; and in the electrolytic arc lamp, from 0·25 to 0·3 watts per c.p. W. H. S.

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1223. *Water-Power for Electrical Purposes.* **R. F. Yorke.** (Elect. Rev. 48. pp. 127–130, Jan. 18 ; Discussion, pp. 170–172, Jan. 25, 1901.)—Paper read before the Glasgow Section of the I.E.E.

1224. *Street Car Building.* **C. H. Davis.** (Street Rly. Journ. 16. pp. 143–146 ; 250–253 ; 312–319 ; 377–383 ; 445–450 ; 513–520 ; 611–616 ; 703–707 ; 827–833 ; and p. 1007, 1900 ; 17. pp. 59–63, Jan., 1901.)—Articles on construction, including drawings.

1225. *Central Station Costs.* (Electrician, 46. pp. 382–388, Jan 4, 1901.)—Tables and diagrams are given showing working expenses, &c, in several stations, more particularly in 1898 and 1899.

1226. *Electric Train-Lighting in Railway Carriages.* **O. May.** (Elektrotechn. Zeitschr. 22. pp. 29–30, Jan. 3, 1901.)—This is a paper read before the Elektrotechnische Gesellschaft at Frankfort in which the advisability of introducing the electric light in trains is discussed. C. K. F.

1227. *German Tramways.* (Elektrotechn. Zeitschr. 22. pp. 119–135, Feb. 7, 1901.) —Statistics relating to the various electric tramways and railways in Germany.

1228. *French Tramways.* **A. Soulier.** (Ind. Élect. 10. pp. 127–135, March 25, 1901.) Tabulated technical particulars are given, referring to the various electrical railways and tramways in France.

1229. *Electrolysis by Earth Returns at Peoria.* **D. H. Maury** and **A. A. Knudson.** (Eng. News, 45. pp. 66–68, Jan. 24, 1901.)—A reply to criticism of the author's paper [Abstract No. 2518 (1900)] by A. B. Herrick [Abstract No. 581 (1901)], with further photographs of pitted Peoria water-pipes. E. H. C.-H.

1230. *Polyphase Electric Traction.* **I. Galmozzi.** (Écl. Électr. 26. pp. 473–480, March 30, 1901.)—This paper contains a theoretical investigation regarding the fall of potential along the overhead conductors and the rail return of three-phase and two-phase systems of traction. The author deduces approximate formulæ for calculating the drop of potential along the conductors. A. H.

TELEGRAPHY AND TELEPHONY.

1231. *Baudot's Quadruplex on Branch Lines.* **F. Luginbühl.** (Journ. Télégraph. 25. pp. 28–31, Feb., 1901.)—Description, with diagrams, of an installation of a distributor of special construction at a central station by which three other stations radiating from this can interchange communications with the central or with each other. The article does not admit of abbreviation, as it is entirely explanatory of the diagrams by lettering.
E. O. W.

1232. *Giltay's System of Harmonic Telegraphy.* **J. W. Giltay.** (Elektrotechn. Zeitschr. 22. pp. 99–100, Jan. 31, 1901.)—At each of the stations in this system, which are arranged in pairs, for example, there is an induction coil, the primary circuit of which includes a battery and a microphone fitted to a König's resonator in communication with a stopped organ-pipe giving the same note as the resonator and capable of being blown continuously in any suitable manner. The secondary of the induction coil is in the line circuit, and is shunted by a condenser and also by a key which normally short-circuits the secondary. There is also connected in the line circuit, a telephone-receiver which is fitted with a König's resonator tuned to the same note as the microphone-resonator and organ-pipe at the other station of the pair, the receiver-resonator at this latter station being tuned to the same note as the microphone-resonator and organ-pipe of the former station. When the key at either station of the pair is depressed to remove the short-circuit from the corresponding secondary, an alternating current of definite periodicity passes into the line and causes the receiver-resonator at the other station of the pair to resound, the resonators at the remaining stations not being affected since they are tuned to different notes. Signals can be sent by the Morse code. Some experiments are described and diagrams are given of the connections.
C. K. F.

1233. *Explosion of Mines by Wireless Telegraphy.* **A. Breydel.** (Soc. Belge Élect., Bull. 18. pp. 13–15, Jan., 1901.)—An arrangement of the usual form is described, the only peculiarity being that the whole is enclosed in a metal box, having only a small opening at one side to admit the rays from the transmitter. No vertical wire or collector of any kind is used, hence the apparatus is probably very insensitive. The author remarks that tubes containing rarefied gases are more sensitive than metallic coherers to electrical radiations, and may be used with advantage.
J. E.-M.

1234. *A New Photophone.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 22. pp. 196–198, Feb. 28, 1901.)—Basing his experiments on the discoveries and inventions of Graham Bell, Simon, and Duddell, the author describes an ingenious form of photophone in which the transmitter is an electric arc, and the receiver a selenium cell in circuit with a local battery and recording apparatus. It is suggested that such an apparatus could with great ease be fitted on board ship for signalling purposes, the arc of a searchlight being used as transmitter. As the system is telephonic, the messages would only be received by the ship on which the ray of light was directed.
J. E.-M.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1901.

GENERAL PHYSICS.

1235. *Form of Volumometer.* **F. W. Jones.** (Chem. News, 83. pp. 100-101, March 1, 1901.)—The author describes a form of volumometer, designed for the determination of the specific gravity of explosives containing ingredients soluble in water. The instrument consists of a gas burette with stopcock, connected at the lower end with a reservoir of mercury and at the upper end with a bottle of small capacity, resting on a spring platform. This bottle has another opening in the stopper fitted with a stopcock. The method of experiment to determine specific gravities is described, and a table of results obtained with the apparatus is given. From this table the author concludes that it is possible by such an apparatus to obtain specific gravities accurate to the second place of decimals. W. C. H.

1236. *Viscosity of Water.* **E. R. Drew.** (Phys. Rev. 12. pp. 114–120, Feb., 1901.)—The determination of the viscosity of water which is here described was carried out by means of an apparatus which consists essentially of two vertical coaxial cylinders, the outer capable of rotating at any desired speed, while the inner, which is closed at the ends, is suspended by means of a torsion wire between agate bearings in the axis. The liquid used is contained in the space between the two cylinders. The apparatus was constructed by E. L. Johonnott under the direction of Professor Michelson, and it was not known at the time that Professor Perry had previously made use of the idea of coaxial cylinders for the same purpose. Perry has given the complete mathematical theory. (See "Liquid Friction." Phil. Mag. 435-441, 1893.)

The author found for the value of the coefficient of viscosity of water, μ, at 20° in two experiments, (1) $\mu = 0{\cdot}01023$, (2) $\mu = 0{\cdot}01020$, expressed in dynes.

The value deduced from the observations of Poiseuille by the formula given by Helmholtz is $\mu = 0{\cdot}0101$. J. J. S.

1237. *Normal Component of Gravitation at Sea-Level.* **F. R. Helmert.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 14. pp. 328–336, March 14, 1901. Abstract of the report presented by the author to the International Geodetic Conference at Paris, September, 1900.)—This report concerns pendulum observations made during the nineteenth century all over the globe. Values for g from small islands in the deep sea and also from high mountains are

excluded. Continental values and those on coast lines are kept apart; they agree closely, however. The reductions to sea-level are made on the Vienna system of the Militär-Geographische Institut of Vienna. The final means are:

$$\gamma_0 = 978{\cdot}046\left\{1 + 0{\cdot}005302\sin^2\phi - 0{\cdot}000007\sin^2 2\phi\right\} \text{ cm.}$$

or— $$\gamma_0 = 980{\cdot}332\left\{1 - 0{\cdot}002644\cos 2\phi + 0{\cdot}000007\cos^2 2\phi\right\} \text{ cm.}$$

with a reciprocal ratio $1 : \varkappa = 298{\cdot}3$. H. B.

1238. *Variation of the Rigidity of Vulcanised India-Rubber with Tension.* **T. C. Hebb.** (Nova Scotian Inst., Trans. 10. pp. 273–286, 1900.)—The author describes experiments undertaken for confirming or otherwise some experiments made by W. A. Macdonald at Dalhousie College that the rigidity (kinetically determined) of a fresh or partially fatigued vulcanised rubber cord, when subjected to increasing tension, at first diminished, then reached a minimum, and finally increased; while in the case of a sufficiently fatigued cord, the minimum point seemed to disappear. These results were confirmed; the author also found that increase of tension in a cord that has been under tension for some time immediately decreases the rigidity, but that if the cord is left under the tension the rigidity increases again. E. C. R.

1239. *Deductions from Capillary Phenomena.* **A. Einstein.** (Ann. d. Physik, 4. 3. pp. 513–523, March, 1901.)—By thermodynamical reasoning and the experimental facts of the phenomena of capillarity the author puts forward the view that the energy of the surface of a liquid is of the nature of potential energy expressible by a certain equation. In this equation occurs a coefficient, c_a, characteristic of the particular atom to which it refers. After passing in review a number of organic compounds, it is concluded that with increasing atomic weights the value of the constant c_a usually increases, but not always, and not proportionally. It is hoped that further researches in this direction will clear up the subject. E. H. B.

1240. *Theory of Solids.* **W. Voigt.** (Ann. d. Physik, 4. 3. pp. 567–591, March, 1901.)—A criticism of the older views as to solids. The author commences by attacking the theory which assumes that the behaviour of a solid is expressible by a few constants throughout its substance, including the *surface*. He next objects to the laws of homogeneous strain being applied without modification to cases of heterogeneous strain. The remainder of the article is devoted chiefly to a discussion of Mohr's rule, and the conclusion is drawn that we are still in need of much searching experiment before a satisfactory theory of solids can be framed. E. H. B.

1241. *Mechanical Oscillations in a Wire Carrying a Current.* **O. Viol.** (Ann. d. Physik, 4. 4. pp. 734–761, April, 1901.)—A discharge is sent from an influence machine through a spark-gap and then along a stretched wire. Nodes and internodes are shown in the wire by the luminosity of the former. When the wire is mechanically vibrated the luminous nodes appear according to the usual laws. The wire must be thin to show these effects. Photographs are reproduced showing with great clearness the whole node systems. P. E. S.

1242. *A Theorem on Fourier's Series and its Application to Geophysics.* **A. Nippoldt.** (Phys. Zeitschr. 2. pp. 363–365, March 16, 1901.)—The author

succeeded in showing that the field to which, according to Schuster and Bezold, are to be ascribed the daily variations of the earth's magnetism, consists of two parts, of which one corresponds to the solar the other to the terrestrial effect. Both have a period of 24 hours. The solar portion is the first term in the Fourier series, the terrestrial portion includes all the other terms.

The writer gives a simple theorem, as useful for this and other applications to geophysics. He calls it the coefficient theorem. Let—

$$f(t) = a_0 + \Sigma p_n \cos nt + \Sigma q_n \sin nt.$$

Further let $f(t)$ be a linear function of the independent variable, $x_1, x_2, \ldots x_m$, and let x_m be capable of expansion in the form—

$$x_m = (a_0)_m + \Sigma(p_n)_m \cos nt + \Sigma(q_n)_m \sin nt.$$

Then the problem is to find what functions p_n, q_n are of $(p_n)_m$, $(q_n)_m$.

From the independence of $x_1, x_2 \ldots x_m$ it follows that $f(t) = \Sigma_1^m c_m x_m$, whence—

$$a_0 = \Sigma_1^m c_m (a_n)_m,$$
$$p_n = \Sigma_1^m c_m (p_n)_m,$$
$$q_n = \Sigma_1^m c_m (q_n)_m.$$

In other words, the amplitude of the nth excited wave depends only on the nth exciting wave. The application of the theorem to several meteorological questions is explained. S. H. B.

1243. *Parameters of Crystal Physics and Directed Quantities of a Higher Order.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 4. pp. 355–379, 1900.)—The author divides the magnitudes which form the subject of this paper into orders, thus—

First order, the *vectors* x, y, z.

Second, the *tensors* $x^2, y^2, z^2, \sqrt{2}yz, \sqrt{2}xz, \sqrt{2}xy$.

Third, $x^3, y^3, z^3, \sqrt{3}x^2y$, and six other corresponding products, and so on to the fourth order.

The following theorem is fundamental. If a scalar S be any arbitrary function of a system of orthogonal variables, then every first differential coefficient according to one of these variables is symmetrical in relation to the transformation properties of these variables. An example is given wherein S is a function of $X_1 \ldots X_n$, and these variables are transformable into $Y_1 \ldots Y_n$ by the relations—

$$X_h = \Sigma_i a_{hi} Y_i, \quad Y_\kappa = \Sigma_\gamma a_{\gamma\kappa} X_\gamma.$$

Thus we have—

$$\frac{dS}{dY_1} = \frac{dS}{dX_1}\frac{dX_1}{dY_1} + \&c.,$$

and therefore—

$$\frac{dS}{dY_\kappa} = \Sigma_\gamma a_{\gamma\kappa} \frac{dS}{dX_\gamma};$$

a special case of importance is when S is a linear function.

The author discusses the separate orders and gives known physical examples. Five principal cases are discussed.

First a scalar linear in three vector components, $S = h_1V_1 + h_2V_2 + h_3V_3$. Here h_1, h_2, h_3 are themselves vectors in directions of the co-ordinate axes. As an example of this form, in thermoelectricity the free energy per unit of

volume corresponding to a small change of temperature τ is given by the expression—

$$\xi = -\tau(r_1X + r_2Y + r_3Z),$$

where X, Y, Z are the components of the electric field. Hence are obtained the components of electric moment,

$$\alpha = -\frac{d\xi}{dX} = r_1\tau, \quad \beta = r_2\tau \quad \gamma = r_3\tau.$$

The resultant of r_1, r_2, r_3 is the moment corresponding to unit increase of temperature.

The second case is that of a scalar linear in six tensor components. This is illustrated by thermomechanical phenomena in crystals.

Then thirdly a scalar bilinear in twice three vector components of the form—

$$\begin{aligned} S = U_1(n_{11}V_1 + n_{12}V_2 + n_{13}V_3) \\ + U_2(n_{21}V_1 + n_{22}V_2 + n_{23}V_3) \\ + U_3(n_{31}V_1 + n_{32}V_2 + n_{33}V_3), \end{aligned}$$

which is a relation of frequent occurrence in the theory of crystals.

The fourth case treated is that of a scalar bilinear in three vector and six tensor components, and the fifth a scalar bilinear in twice six tensor components.

The writer concludes that the parameters of crystal physics are generally referable to directed magnitudes of the first to the fourth order, and that in many cases these magnitudes have a distinct physical significance. S. H. B.

1244. *Propagation of Waves through a Heterogeneous Medium of Lamellar Structure.* **N. Kasterin.** (Archives Néerlandaises, 5. pp. 506–515, 1900.)—In treating this very difficult problem the author begins with the simplest conceivable case. We are to suppose a series of laminæ containing gas numbered consecutively 1, 2 . . . N. For the first lamina a is the thickness, ρ_1 the density of gas within it, Ω_1 the velocity. For the second lamina a, ρ_1, Ω_1 are replaced by b, ρ_2, Ω_2, and so on. Acoustic waves only are first treated. The laminæ are all at right angles to the axis of x. The period, T, of the oscillation in any lamina is a function of x and of the time only. The co-ordinates of the edges of the laminæ are in order x_0, x_1, x_2, &c., so that if x be the co-ordinate of any point within the $(m+1)$th lamina, $x_{2m} \leqq x \leqq x_{2m+1}$. If ϕ_{2m+1} be the velocity potential, ϕ_{2m+1} satisfies the equation—

$$\frac{\partial^2\phi_{2m+1}}{\partial x^2} + k_1^2\phi_{2m+1} = 0.$$

Similarly—

$$\frac{\partial^2\phi_{2m+2}}{\partial x^2} + k_2^2\phi_{2m+2} = 0.$$

Here—

$$k_1 = 2\pi/T\Omega_1 \quad k_2 = 2\pi/T\Omega_2.$$

Hence, making use of the terminal conditions for each lamina we obtain a system of $2(N-1)$ linear differential equations containing $2N$ unknown constants, and it is then proved that for all possible values of N_1 and for arbitrary values of k_1a, k_2b, &c., it is always possible to reduce these to six linear differential equations with eight unknown constants.

Our author defines a function k' (equation 18) by—

$$\cos k'(a+b) = \cos k_1a \cos k_2b - \tfrac{1}{2}\left(\frac{k_1\rho_2}{k_2\rho_1} + \frac{k_2\rho_1}{k_1\rho_2}\right) \sin k_1a \sin k_2b.$$

From which the dependence on k' of the period T can be found. Then he

makes $k' = n(1 - i\epsilon)\Omega T_1$ where $i = \sqrt{-1}$, and ϵ is the *absorption coefficient*. From the equation thus obtained the curves can be drawn showing graphically the phenomena of absorption and dispersion.

It is remarked that the formulæ obtained hold also for electromagnetic waves, if by ϕ (which is the velocity potential in the investigation of the present paper) we understand the electric force at right angles to the axis of x, *i.e.*, to the direction of propagation. Also that by the analogy between the passage of waves in a heterogeneous medium and that of light waves, the theory developed in this paper can be applied to explain the acoustic opacity of the atmosphere and Lipmann's colour photography. S. H. B.

1245. *Physical Constitution of the Sun.* **K. Birkeland.** (International Physical Congress at Paris, Report, 3. pp. 471–487, 1900.)—*Section* I.—Sun-spot observations are discussed with the view of testing the hypothesis that the spots are manifestations of periodic eruptions from persistent centres of eruption in a relatively stable nucleus rotating uniformly in the interior of the sun. A remark of G. H. Darwin's is quoted, to the effect that we have no data as to the mechanical properties of matter at 10,000° F. and a pressure of many tons to the square inch, that a gas under such conditions may have the density of mercury and rigidity of granite. The writer considers that facts support the hypothesis, but that further observations at the next maximum are needed to confirm it. He makes the period of rotation 25·149 days.

Section II.—The same observations are here examined with the object of determining whether the influence of the planets Mercury, Venus, and Jupiter can be traced. The writer finds that it can in spite of the smallness of the planets' attraction, and he considers that this tends to confirm the above hypothesis of a quasi-solid solar nucleus. A. E.

1246. *Solar Constant.* **A. Crova.** (International Physical Congress at Paris, Report, 3. pp. 453–470, 1900.)—The means employed for measuring the intensity of the sun's thermal radiation at the earth's distance, and the formulæ used in reducing the observations, are discussed at length. The writer infers that the true value of this "solar constant" must be at least 3 therms per minute per square centimetre, and may be found to be 4 therms or more as observing conditions improve. The better the conditions, and the higher the elevation, the greater the values obtained hitherto. A. E.

1247. *Heat of Stars and Planets.* **E. F. Nichols,** with **A. L. Colton** and **C. E. St. John.** (Astrophys. Journ. 13. pp. 101–141, March, 1901.)—The author describes a series of observations of the heat radiation of Arcturus, Vega, Jupiter, and Saturn made at the Yerkes Observatory in the summers of 1898 and 1900. A very detailed account is given of the heat-measuring instrument used, which was of the same type as the compensating torsion radiometer, of which a description has appeared (Physical Review, iv. 297; also Wied. Ann. 60. 401, 1897). The apparatus was tested upon two candles at stations at different distances (2,500 and 4,500 feet), so far away that the radiometer sensitiveness could be determined with the same mirrors used in the star observations. The radiometer was found to be twelve times as sensitive as the radiomicrometer of Boys (Proc. R. S. 47. 480, 1890), which gave a deflection of 60 mm. for a candle 60 inches distant. The concave mirror was also larger—24 inches diameter as against 16 inches. Thus the radiometer combined with its mirror, whenever the full aperture could be utilised, was over twenty-six times as sensitive as the apparatus used by Boys.

The small amount of heat detected in the present observations readily accounts for the negative result of the radiomicrometer measurements. The following are the relative thermal intensities of the means, reduced to the zenith, expressed in 10^{-8} metre candles: Vega, 0·51; Arcturus, 1·14; Jupiter, 2·38; Saturn, 0·37. The ratio of the zenith photometric intensities is: Vega : Arcturus : Jupiter :: 1 : 1 : 7·8. Thus Arcturus would appear to have a proportionately more intense infra-red spectrum than Vega. Although the results so far gained are to be considered only in the roughest sense quantitative, they are useful in supplying a basis for calculating the necessary aperture of mirror and suggesting further refinements in the radiometer. A 5-foot concave mirror could be effectively employed, even with the same radiometer. A. E.

1248. *Reduction of Measures of Stellar Photographs.* **H. G. v. d. Sande Bakhuyzen.** (Archives Néerlandaises, 5. pp. 542–548, 1900.)—This paper chiefly concerns those connected with the work of the International Photographic Star Chart. When deducing the right-ascensions of stars from their co-ordinates referred to rectangular axes on the plate, calculators are cautioned to notice that δ, the declination of the origin, has different meanings in different formulæ of reduction. A simplification in the formulæ is suggested by taking as axis of y on the plate, instead of the apparent hour-circle, its position after correcting for refraction and aberration. A. E.

1249. *Danish Polar Light Expedition to Iceland, Winter* 1899–1900. **A. Paulsen.** (International Physical Congress at Paris, Report, 3. pp. 438–452, 1900.)—A brief account of this expedition has already been given by Neesen [see Abstract 351 (1901)]. The strong auroral rays [Abstract No. 999 (1900)] appear on the plates even when no aurora is visible. In determining the electric potential of the atmosphere, a metallic disc collector, 13 cm. in diameter, was used, whose surface was covered with filter paper rubbed with a powder supplied by Curie, which emits Becquerel rays; thus the disc was brought to the potential of the air surrounding it. The ascending wind currents on the mountain observatory, at an altitude of 1,200 m., were so rapid that the barometer fell by 12 mm. within a few seconds; these pressure variations were painful to the ears of the observers. The variations in the electric potential were less marked at this altitude than at the other observatory, 50 m. above sea-level; auroræ had an effect only when near the zenith. The electric discharge was determined by means of the metallic cylinder of Elster and Geitel; the discharges proved different for negative and for positive electricity. H. B.

1250. *Fog Studies on Mount Tamalpais.* **A. G. McAdie.** (Monthly Weather Rev. 29. pp. 24–25, Jan., 1901.)—Two photographs are given of fog billows. The wave-lengths were estimated as varying between 100 and and 2,000 m. The fogs and billows distinctly interfere with the audibility of the siren signals. [See further Abstract No. 602 (1901).] H. B.

1251. *Eclipse Cyclone of the Solar Eclipse of May* 28, 1900, *and Diurnal Cyclones.* **H. H. Clayton.** (Amer. Acad., Proc. 36. pp. 307–318, Jan., 1901.)—The penumbra, or entire eclipse area, had a diameter of about 5,000 miles; the eclipse travelled with a velocity of 2,000 miles an hour. The wind and temperature observations from stations all over the southern and central portions of North America indicate an outflow of wind from around the

umbra and an inflow around the border of the penumbra. These winds were reversed in direction as the umbra moved from the western over to the eastern coast of the United States. The synoptic chart shows an anticyclonic condition around the centre of the eclipse, extending to a distance of about 1,500 miles from the umbra; and outside this area a cyclonic circulation, 1,000 miles in width, extending beyond the edge of the penumbra. An elliptical area of cold followed the umbra, lagging behind by 500 miles. This temperature depression amounted at Wadesboro', in N.C., to 8° F. at 9 a.m.; it was less at stations where the sky was cloudy and diminished with the height above the sea. The curve of Napier Denison's ærograph at Toronto marks a barometric depression during the eclipse period, with an upward swell, shortly preceding the middle of the eclipse, and further a ring of high barometric pressure just before the beginning and after the end of the eclipse, and thus surrounding the umbra. The central swell was more marked at stations in the path of totality; it is due to the increased density of cold air, and on it depends the outflow of air surrounding the umbra. The barometric records are in perfect agreement with the pressure distribution, demanded by the wind circulation, and the phenomena are those of a cold air cyclone of Ferrel (with a cold centre, as distinct from a hot centre cyclone), which is here directly caused by a fall of temperature and not complicated by condensation of vapour, nor the meeting of air currents. This eclipse cyclone moved with a velocity of 2,000 miles an hour, without any apparent dynamic lag due to the inertia of the air. Any given particle of air, moving with the velocity of the eclipse winds, could not have travelled more than 5 miles during the passage of the eclipse, and we have, therefore, a certain analogy to a wave motion. Cyclones can thus develop and dissipate in the air with a wonderful rapidity and move with their originating cause, and not only by drifting. The author explains the double period in the diurnal variations of the air pressure by two diurnal cyclones, the one developed by the cold of the night, the other by the heat of the day. These cyclones move from east to west (contrary to the ordinary cyclones of the temperate zones) with a velocity which is 1,000 miles per hour at the equator and decreases towards the poles. The hypothesis would also account for the third barometric maximum in high northern latitudes during the winter.

H. B.

1252. *Diurnal Periodical Oscillations of the Earth at Triest.* **E. Mazelle.** (Akad. Wiss. Wien, Sitz. Ber. 109. 1. pp. 527–651, 1900.)—This paper, essentially tabular, deals with the daily movements of the photographic recording triple horizontal pendulum of Rebeur-Ehlert [see Abstract No. 2398 (1900)] at Triest for the year September 1898-99. The pendulum is mounted on a limestone pillar, 70 cm. long, 60 cm. wide, 130 cm. high, resting in the basement of the Observatory on cement and sandstone over sandstone rock. The three pendulums show one diurnal period (one maximum and one minimum) for the summer months, and a double period for the months November to March. The resulting diagrams for the movements of the pillar are elongated ellipses with a major axis from E. 20° N. to W. 20° N. for the summer months and irregular curves for the winter months. H. B.

1253. *Damping Seismological Instruments.* **O. Hecker.** (Zeitschr. Instrumentenk. 21. pp. 81-83, March, 1901.)—The author attaches to the horizontal axis of a pendulum an aluminium cylinder, 7 cm. in height and 3·5 cm. in diameter, and surrounds this cylinder by another stationary one, leaving an

annular space, 4 mm. in width, between the two cylinders. Vertical air currents are prevented by mica plates. Comparative diagrams demonstrate a very remarkable effect of this damping. An undamped pendulum of the same type marked some fresh impulses of an earthquake wave by a diminution in the amplitude of the oscillations, and others by a gradual increase in the amplitude, neither of which probably had any existence. H. B.

1254. *Theory of Atmospheric Condensation on Mountains.* **F. Pockels.** (Ann. d. Physik, 4. 3. pp. 459–480, March, 1901.)—Where a ridge of mountains rises from a plane, the slope exposed to the predominating winds receives more rain than the other slope and the plane. The author deals quantitatively with the problem, and bases his calculations on the Hertz tables for adiabatic changes in moist air. For a mountain rising with a gentle slope to 950 m. above the plane the maximum condensation would, when the plateau-like top of the mountain is below the base of the clouds, fall on the spot where the gradient is a maximum ; the upper half of the slope would receive comparatively less rain ; the lower half and even the plane adjoining the foot of the mountain more than we might expect. No definite allowance can be made in these calculations for the transport of condensed moisture within the horizontal air currents, whereby the maximum deposit is shifted more towards the top. If the mountain reaches into the clouds, the condensation will essentially depend upon the slope and follow a cosine law. So far the author has presumed that the temperature distribution in the air currents which strike the mountain is identical with that which results in an ascending air current This does not agree with balloon observations. Bearing this point in mind, the author finally calculates the winter and summer rainfalls for four slopes, culminating at heights between 2,940 and 5,100 m. There is always a zone of maximum condensation, and in general the slope is of greater influence than the absolute elevation. Observations made on high mountains would confirm these conclusions. H. B.

1255. *Line Integrals in the Atmosphere.* **F. H. Bigelow.** (Monthly Weather Rev. 28. pp. 535–537, 1900.)—The paper by Bjerknes [Meteorolog. Zeitschr., March and April, 1900 ; Abstract No. 1406 (1900)] has been criticised by M. Möller (*ibid.*, June, 1900), to which Bjerknes replies (*ibid.*, Nov., 1900) ; and J. W. Sandström has applied the theory of Bjerknes to cyclones (Swedish Acad., Jan., 1900). The author discusses this latter paper, and shows that, instead of computing the work integral around the circuit by means of the densities derived from observations *in situ* (by ascensions), we can measure the velocities of the air motion at four points by triangulation. The upper and lower point-pairs need not necessarily be on the same isobar. The Report of the Chief of the Weather Bureau on International Cloud Observation would contain material in proper form for such computations. H. B.

1256. *Squalls and Secondary Depressions.* **E. Durand-Gréville.** (Revue Scientif. 15. pp. 263–269, March 2, 1901.)—This paper discusses the squalls of Abercromby. A centre of depression is surrounded by concentric isobars with peculiar V-shaped prominences, the V of the consecutive isobars lying on a curved or zigzag band (*le grain*) of calms which separates the wind from S.W. from the N.W. wind on its front. The phenomena are connected with the "Sturmlinien" of Bezold. The author claims to have followed the advance of such a storm-line from Ireland to St. Petersburg, a distance of

1,500 km., on August 27–28, 1900. He does not quote any data in support of this view, however, and his chief object seems to be to disprove the existence of secondary depressions which Sprung assumed in explanation of the V. H. B.

1257. *Barometric Data for Weather Forecasts.* **J. Bosscha.** (Archives Néerlandaises, 5. pp. 529–541, 1900.)—The question of the reduction of barometric data has been discussed but little since the Vienna Meteorological Congress of 1873. This Congress recommended reductions of all data from stations less than 300 m. above sea-level to sea-level. Although all the stations of the Netherlands belong to that category, Buys Ballot, director of the Meteorological Institute of the country, insisted upon recording deviations from the so-called normal barometric values as derived from the means of observations extending over many years. Accepting Haga's observations at Groeningen for 1897, the author proves that the value of those normals is illusory, because they are deceptive in themselves, and, moreover, referred for different periods to different stations. Thus the Helder normal rests partly on the Helder reductions and partly on calculations made at Carlsruhe, Greenwich, Paris, or Vienna. The result is that the comparative data from the four stations of the Netherlands, at Vlissingen, Helder, Groeningen, Maastricht, may indicate barometric equilibrium over the country when there is none, and *vice versâ*. H. B.

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1258. *Comparison between the Sun's Light and that of Stars.* **C. Dufour.** (International Physical Congress at Paris, Report, 3. pp. 488–494, 1900.)—The writer relates some experiments made on board lake steamers by noting at what point of the course the light of a gas-lamp on the quay appeared equal to that of a star. A. E.

1259. *Circulatory Movements in the Atmosphere.* (Monthly Weather Rev. 28. pp. 532–535, 1900.)—Mathematical extracts from an article by **V. Bjerknes** in the Meteorolog. Zeitschr., Nov., 1900, referring to his theory [see Abstract No. 1406 (1900)]. H. B.

LIGHT.

1260. *Pressure of Light Rays.* **D. A. Goldhammer.** (Archives Néerlandaises, 5. pp. 467–483, 1900.)—Bartoli found that in total reflexion there is a pressure p on the reflecting surface equal to $2e$, where e is the energy per unit of volume. Boltzmann from thermodynamic considerations found that with a perfect vacuum space enclosed by heat-proof walls with normal incidence, $p = e$, or $p = 2e$ according as the surface is absorbent or perfectly reflecting. According to Maxwell (art. 792), there is a pressure normal to the waves and numerically equal to the energy in unit of volume. This is interpreted by Boltzmann to apply to absorbed waves. For perfect reflexion the pressure should be twice as great.

The present writer says that from Maxwell's theorem we cannot directly infer ponderomotive forces to exist at the interface of two media, but the resultant only of those forces which, according to known formulæ of elasticity, arise from the stresses in the interior of every substance. These resulting forces can be calculated only in the limiting case of normal incidence on a perfectly black body. Also the deductions are not correct unless the ponderomotive forces consist only in Maxwell's pressure, that is, unless the electromagnetic tensions give rise to no forces acting in the body itself.

The writer considers a conducting medium, capable of polarisation, moving with velocities α, β, γ. To this he applies Hertz's formulæ, of which the type is—

$$A\mu\left\{\frac{dL}{dt}+\frac{\partial}{\partial y}(\beta L-\alpha M)-\frac{\partial}{\partial z}(\alpha N-\gamma L)+\alpha\left(\frac{\partial L}{\partial x}+\frac{\partial M}{\partial y}+\frac{\partial N}{\partial z}\right)\right\}$$

$$=\frac{\partial Z}{\partial y}-\frac{\partial Y}{\partial z},$$

coupled with—

$$A\varepsilon\left\{\frac{\partial X}{\partial t}+\frac{\partial}{\partial y}(\beta X-\alpha Y)-\frac{\partial}{\partial z}(\alpha Z-\gamma X)+\alpha\left(\frac{\partial X}{\partial x}+\frac{\partial Y}{\partial y}+\frac{\partial Z}{\partial z}\right)\right\}$$

$$=\frac{\partial M}{\partial z}-\frac{\partial N}{\partial y}-L\pi A u.$$

Multiplying these equations in order by L, M, N, X, Y, Z, and integrating through the space within a closed surface, he obtains expressions for the ponderomotive forces acting on the bounding surface and in the interior. He then supposes the medium to be initially at rest, and a disturbance to pass through it of the usual form—

$$A\mu\frac{\partial L}{\partial t}=\frac{\partial Z}{\partial y}-\frac{\partial Y}{\partial z}\ \&c.$$

$$A\varepsilon\frac{\partial X}{\partial t}=\frac{\partial M}{\partial z}-\frac{\partial N}{\partial y}-L\pi A u,\ \&c.$$

In order, then, to find $\alpha\beta\gamma$, the forces so obtained are treated as external forces acting on an elastic body.

We are concerned, not with the instantaneous values, but with the time

averages of the forces here in question. The disturbance is supposed to be periodic, of the form $a\cos\left(b - \frac{2\pi t}{T}\right)$ with period T.

The author then takes the plane $z = 0$ for the reflecting surface, and $x = 0$ for plane of incidence. And if ϕ be the angle of incidence, e_0 and e_r the energies per unit of volume of the incident and reflected wave respectively, we find that from the incident and reflected light there results a pressure p, in a direction making with the normal an angle $\psi = \tan^{-1}\frac{e_0 - e_r}{e_0 + e_r}\tan\phi$, and whose value is $p = \cos\phi\ \sqrt{e_0^2 + e_r^2 + e_0 e_r \cos 2\phi}$.

If then J_ϕ be the coefficient of reflexion, we have $\tan\psi = \frac{1 - J_\phi}{1 + J_\phi}\tan\phi$,

$$p = e_0\cos\phi\ \sqrt{1 + J_\phi^2 + 2J_\phi\cos 2\phi},$$

whence— (1) for *perfect reflexion* $\psi = 0, p = 2e_0\cos\phi$;

(2) for *perfect absorption* $\psi = \phi, p = e_0\cos\phi$;

(3) for *normal incidence* $\psi = 0\ p = e_0(1 + J_0)$.

Of these results (2) agrees with Maxwell, (1) with $\phi = 0$ agrees with Boltzmann.

Next, the author considers the force on the other side of the reflecting surface, and finds in case of complete absorption zero force in the normal, but a force tending to rotate the plane about the normal. For a perfectly transparent medium with normal incidence he finds for the pressure of light on the further side of the surface $p = 2(e_0 - e_d)$, where e_d is the energy per unit of volume in the second medium. And this can be put in the form—

$$p = \frac{e_0 4J_0}{1 + J_0};$$

or if $J_1 = \frac{1}{3}, p = e_0$, as in the case of a black body. In the last section is treated a case of special interest in which the incident light is polarised at right angles to the plane of incidence. If the second medium be a plate movable in the direction of the normal, it is found that there is a force tending to rotate it. S. H. B.

1261. *Reversibility of Radiation.* **J. D. van der Waals, Jr.** (Archives Néerlandaises, 5. pp. 587-594, 1900.)—The author first reviews the Planck-Wien controversy as to whether the free propagation of radiation is a reversible or irreversible phenomenon, the test of the reversibility being the constancy of the entropy. He then introduces two new tests for perfect reversibility other than that of the constancy of entropy. According to these tests the conditions of reversibility are : (1) Is it always in our power to accomplish the action in the reverse sense? (2) Would the reverse action occur accidentally with the same probability as the direct action?

Applying these tests to the radiation problem he concludes—

(1) It is easy to see that an arbitrary reversal of the radiation is scarcely possible. Even if we could use a perfectly reflecting sphere surrounding a small radiating sphere the rays would not all fall normally on the spherical surface, and consequently would not be reflected back along the paths of incidence. The rays from one molecule would not converge after reflection towards the same molecule, but would come to a focus at another point where at that moment possibly no molecule was present. Thus, we could not obtain exactly the same action in the reverse direction.

(2) The energy emitted by a molecule presents a symmetry around that molecule. If, then, one surrounds a radiating sphere by a concave mirror, or by a concave body at the same temperature, there will fall on each molecule on the average the same energy as it radiates, since it maintains a constant temperature ; but the symmetry around the molecule is absent from the radiation incident on the molecule. The incident radiation cannot, then, from all points of view be considered as the reverse of the radiation emitted. Thus free propagation of radiation ought rigorously to be considered as irreversible. J. B. H.

1262. *Diffraction of Light of Variable Intensity.* **H. M. Reese.** (Astrophys. Journ. 13. pp. 199–207, April, 1901.)—This investigation was undertaken to determine if any noticeable disturbance of the resolving power of a spectroscope was produced by the absorption of the very dense glasses now in use. After developing the formulæ devised, they are applied to the case of the new Mills spectrograph at the Lick Observatory, the result being that the resolving power of that instrument is not diminished by more than 0·5 per cent. by the absorption of the prisms.

Diagrams are given showing the forms of the lines with and without consideration of the absorption. C. P. B.

1263. *Doppler's Principle.* **W. Michelson.** (Astrophys. Journ. 13. pp. 192–198, April, 1901.)—The author extends the investigation on the variation of the wave frequency with motion either of source or observer, or both, to include cases not considered by the ordinary formulæ in use.

The usual assumptions on which the principle is based are—(1) that the period of vibration of the source is not influenced by its motion along the line of sight ; (2) that the medium carrying on the waves is at rest as a whole, and that its properties are not changing.

The present investigation refers more particularly to the second supposition, and formulæ are derived expressing the impressed change of wavelength due to movement of a layer of vapour through which the light has to pass. It is deduced that if a region of *increasing density* be made active, the rays are displaced towards the *red*, while a decrease of density of the transmitting medium causes a shift towards the violet.

This will have a most important bearing on the frequently observed distortions of the spectral lines over the regions of sunspots, prominences or faculæ, as, by this reasoning, velocity in the line of sight may only cause part of the change, and further, a translation of one kind of matter, say hydrogen or iron vapour, may involve distortions of the lines of quite different elements, say those of helium, calcium, &c. C. P. B.

1264. *Influence of the Medium on the Photochemical Effect in Silver Bromide Emulsions and Photochemical Induction.* **R. Abegg** and **C. Immerwahr.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 974–980, 1900.)—The researches of Luggin and of Luther [Abstract No. 1113 (1900)] have shown that the action of light on silver haloid compounds finally results in a state of chemical equilibrium, which is defined by a definite potential (gas-pressure, e.m.f., or solution concentration). This state is, however, never reached in ordinary photographic processes, firstly because the time of exposure is too brief, and secondly because the halogen liberated from the silver salt is removed from the sphere of action either by diffusion or by combination with the gelatine or other medium employed. It is this latter which is probably the cause of

the superior sensitiveness of gelatine plates as compared with those made with collodion, a comparatively inert substance. But although the ease with which the gelatine takes up the halogen favours the photochemical effect, the medium also exerts a retarding influence in that it prevents the escape of halogen by diffusion. This may be shown by exposing two similar plates, one with the gelatine, and the other with the glass towards the light. The action is less in the latter than in the former case, the diffusion of the halogen being hindered by the proximity of the glass plate to the sensitive film. N. L.

1265. *Apparatus for Demonstrating the Doppler-Fizeau Principle.* **A. Bélopolsky.** (Astrophys. Journ. 13. pp. 15–24, Jan., 1901.)—The principle of the apparatus was suggested by the author in 1894, and he has recently been enabled to construct it. By means of successive reflections from rapidly revolving mirrors, the wave-length of incident light is altered. The spectrum of solar light was compared with the spectrum of the same light after reflection from the moving mirrors, and the lines were found to be sensibly displaced. A detailed description and results of first experiments are given. A. E.

1266. *Ocular Accommodation.* **M. Tscherning.** (International Physical Congress at Paris, Report, 3. pp. 547–560, 1900.)—An instrument has been used by the author for studying the aberration of the human eye, and has been called by him the aberroscope. It consists of a plano-convex lens, the plane side of which is ruled in millimetre squares; through the lens a distant object is seen as a circle of diffusion, and the shadows of the line are also seen cast upon the retina. In a state of rest most observers see the lines convex inwards, which indicates a certain degree of ordinary aberration. When an effort is made at accommodation this convexity turns outwards.

When accommodation reaches its maximum it has been noticed that the shadows cast by any irregularities which exist in the media of the eye undergo a displacement which seems to indicate a downward displacement of the crystalline lens. This Hers presumed to be the result of gravity acting on the lens when the suspensory ligament is relaxed. This displacement is not noticed when the eye is directed vertically upwards, as when the person is lying on the back. The author has observed the motion of the image reflected from the upper middle and lower portion of the posterior surface of the crystalline lens of the eye with a telescope during accommodation, and found in the first instance a considerable downward displacement of the reflecting surface, in the second case less, while in the third case the displacement was but slight. He concludes that the phenomena can be explained by supposing that during accommodation the contraction of the ciliary muscle exercises a traction on the fibres of the zonule which are inserted into the anterior surface of the lens, while at the same time the fibres which go to the posterior surface are relaxed. W. C. O.

1267. *Coloured Glasses.* **R. Zsigmondy.** (Zeitschr. Instrumentenk. 21. pp. 97–101, April, 1901.)—This paper is an appendix to the article on the absorption of light in coloured glasses [Abstract No. 784 (1901]. Schott & Co., of Jena, have manufactured various coloured glasses for use as light filters for different parts of the spectrum and for three-colour photography.

The author gives a list of fourteen of these glasses and spectrum curves, showing the absorption. They are severally transparent to the following

wave-lengths : $\mu = 0{\cdot}59$ and beyond, 0·51 and beyond, 0·53 to 0·59, 0·50 to 0·62, 0·49 to 0·70, 0·52 to 0·60, 0·50 to 0·63, 0·49 to 0·57, 0·50 to 0·56, violet to 0·60, to 0·55, to 0·50, to 0·48, to 0·49 with 0·70 and beyond, violet to 0·44 with 0·67 and beyond, violet to 0·45.

The author also mentions combinations of these which are useful for certain purposes. G. H. B.

1268. *Resolution of Light into its Circular Components in the Faraday Effect* **D. B. Brace.** (Phil. Mag, 1. pp. 464–475, April, 1901. Paper read before the American Physical Society, Oct. 27, 1900.)—Fresnel's interpretation of the rotation of the plane of polarisation—the propagation of the light in the medium as two opposite circularly polarised beams—has been applied to the Faraday effect; but has up till now remained without experimental verification. Indirect evidence by interference methods has tended to confirm the principle without, however, conclusively establishing it.

The author, after several failures, has at last succeeded, by means of refraction, in resolving natural light into its two opposite circular components when propagated along the lines of force. In his successful method he employs two equilateral right-angled prisms of very dense glass and a "half-wave" plate of mica, the two prisms being cemented by their diagonal faces to the mica plate so that the combination forms a square prism with the mica plate along one diagonal. The beam of light is introduced into the prism near one end and almost perpendicular to the prism axis. It is introduced through a small auxiliary 45° prism cemented to one of the faces near the end. After being internally reflected round the prism four or five times, it passes out by a similar auxiliary prism near the other end and continues its former direction. The prism is placed in the magnetic field so that the beam in passing once round the prism moves only along and perpendicular to the lines of force. With a field of 8,700, obtained between pole-pieces 10 cm. square and 11 mm. apart by means of a very large magnet weighing two tons, the author has succeeded in separating the two circularly polarised beams in which the beam is propagated while passing through the prism, the angular separation after passing five times round the prism being 0·005 in absolute angular units. This agrees with the value calculated from Verdet's constant. J. B. H.

1269. *Magneto-optical Phenomena.* **H. A. Lorentz.** (International Physical Congress at Paris, Report, 3. pp. 1–33, 1900.)—The various theories put forward to account for the influence of a magnetic field on the emission of light are explained and discussed. In particular it is shown how, from the consideration of a radiating molecule as a material system of μ degrees of freedom, it follows that, if ν of the corresponding frequencies are equal apart from the magnetic field, there results a spectral ray which splits up into ν components under the action of a magnetic field. The author considers Voigt's method to be the only one which enables us to understand the phenomena depending upon the density of the radiating bodies and the width of the spectral lines; however, he looks for its development by the introduction of notions as to what occurs in the molecule, and a replacement of the hypothesis of a resistance proportional to the velocity by a theory of absorption. Finally, from the direct treatment of the emission of a system of interacting molecules, he looks for the explanation, in the case of dissymmetry discovered by Voigt, of the existence of vibrations slightly different in period, some of which determine the radiation in the direction of the field, and others that in the transverse direction. W. E. T.

1270. *Atmospheric Absorption of Visible Rays.* **A. Cornu.** (Astrophys. Journ. 13. pp. 142–148, March, 1901.)—One of the searchlights at the summit of the Eiffel Tower was directed towards the École Polytechnique (in 1889) for the purpose of determining absorption. The distance is about 4,350 metres. The dark lines in the spectrum of the electric light were examined under high dispersion and compared with the author's maps. "It follows from the spectroscopic observations that more than 200 dark lines, produced by the atmospheric absorption of radiations from a terrestrial source of light, have been identified, one by one, with the so-called *telluric* lines observed in the solar spectrum. The atmospheric origin of these lines is thus verified beyond all question." The author remarks that the observations also constituted a direct and valuable test of the *method of oscillating lines* which had led him to distinguish between solar lines and those of terrestrial origin in the most complicated groups of the solar spectrum. A. E.

1271. *Flash Spectrum, Solar Eclipse May* 28, 1900. **H. C. Lord.** (Astrophys. Journ. 13. pp. 149–166, March, 1901.)—Measures of 229 lines on two photographs of the flash are tabulated and discussed, and the apparatus is briefly described. The general conclusion is that "these lines may be completely explained by a reversal of *some* of the Fraunhofer lines combined with a change in their relative intensities, plus those lines due to helium. That the flash spectrum is the reversal of *all* the Fraunhofer lines is far from being borne out by the plates." Of 1,144 solar lines given by Rowland, 60 per cent. are lacking, including many of the brightest lines, especially those due to iron. A table is given of computed elevations above the sun's limb of the upper limit of substances emitting certain lines. The four lines whose elevation comes out greater than 1,000 miles are F, 4,713·67, 4,471·83, and 5,015·80. The last three agree closely with lines found by Runge and Paschen in the spectrum of Cleveite gas; but the behaviour of 5,015·80 is very peculiar, and resembles that of a line at 4,686·28, both showing much more markedly at the horns of the crescent than at the vertex, a peculiarity shared by no other lines. The author thinks these two lines must be common to some substance. Rydberg deduces from formulæ a hydrogen line at 4.687·88 (Astrophys. Journ. vi. 233). The line 4,686·28 may be this hydrogen line. Its intensity, however, is not a tenth that of Hβ or Hγ. A. E.

1272. *Spectra of Carbon Compounds.* **A. Smithells.** (Phil. Mag. 1. pp. 476–503, April, 1901.)—The hydrocarbon flame spectrum, first mapped by Swan in 1857 and generally known as the "Swan spectrum," has since then been the subject of many investigations; in these the spectrum has been attributed to almost all the constituents of the flame except carbon monoxide. Stokes and Smithells were independently led to the idea that the spectrum might really be due to carbon monoxide, and in the present paper the latter describes experiments which he has made during the last eight years with the view of testing this assumption. The experiments strongly support the idea, and a review of the experimental results of former experimenters shows that many of these also uphold the carbon monoxide assumption, while the others which do not directly support it in no case support the direct negative. The paper contains an epitome of a large number of experiments on the spectra of carbon and its compounds. J. B. H.

1273. *Transparency of Matter for Röntgen Rays.* **L. Benoist.** (Comptes Rendus, 132. pp. 545–548, March 4, 1901.)—The laws, enunciated in a

previous paper [see Abstract No. 1074 (1901)], which govern the transmission of Röntgen radiation through matter in various forms are dealt with in further detail on various points. Curves are given showing clearly how the transparency depends on the atomic weight for a large number of elements. Previous work on the same subject is criticised, especially with the view of showing that the relative transparency of bodies for Röntgen rays depends very largely on the quality of the radiation, and that in previous experiments this has not been sufficiently taken into account. It is proposed that this property be made use of as a means for comparing the hardness or softness of the rays. R. S. W.

1274. *Determination of Atomic Weights by Röntgen Rays.* **L. Benoist.** (Comptes Rendus, 132. pp. 772–774, March 25, 1901.)—An interesting and ingenious application of the laws discovered by the author, relating to the transparency of matter to Röntgen rays. [See preceding Abstract and No. 1074 (1901).] It is shown that the atomic weight of an element can be inferred from measurements of its transparency and of that of other elements whose atomic weight is known. These measurements may be carried out either on the element in the pure state or on a mixture or compound of it with others. The method is therefore more general than the one founded on the specific heat law of Dulong and Petit, as the transparency does not depend on the physical state. An application is made to the determination of the atomic weight of indium, chemists having to choose between two possible values, viz., 75·6 and 113·4. The transparency equivalent of the element was deduced from measurements of that of acetylacetonate of indium as well as from observations on the metal itself. Comparing the value so obtained with the values for arsenic and silver by means of his published curves, the author finds 113·4 as the atomic weight, to the exclusion of the smaller value. R. S. W.

1275. *Absorption of Röntgen Rays.* **A. Hébert** and **G. Reynaud.** (Comptes Rendus, 132. pp. 408–409, Feb. 18, 1901.)—A kind of modified Duboscq colorimeter is used, the tubes ending in cardboard covered with guttapercha. The absorptions of saline solutions are compared with that of a column of water 41·5 mm. long. The general result, using nitrates of NH_4, Ba, Cd, Ca, Co, Cu, Li, Mg, Mn, Ni, K, Na, Sr, and Zn, is that the absorption is proportional to the atomic weight of the metal in the salt. The absorption of different acids combined with the same metal seems also to increase with the molecular weight of the acids. In a compound, that element which has the greatest atomic weight has the greatest effect on the absorbing properties of the substance. G. E. A.

1276. *Propagation of Röntgen Rays.* **G. Sagnac.** (Annal. Chim. Phys. 22. pp. 394–432, March, 1901.)—The absence of interference or diffraction fringes is not conclusive proof of rectilinear propagation, the radiations being widely heterogeneous : the spreading of a pencil of rays by diffraction is always related to the wave-length, and with Röntgen rays it is so slight as to show that the wave-length is at any rate 28 times smaller than that of ray D. This result was obtained by the author with the original tubes ; since then, focus tubes have shown (Gouy, Haga and Wind) that the wave-length would be 2,000 times less than that of the green, for those rays which have traversed glass, air, and thin wood or black paper. Refraction, dichroism, double dichroism, all give negative results, more or less obscure where the crystals used are themselves dichroic. The absorption of Röntgen

rays appears independent of the crystalline structure of the substance, and presents a character chiefly atomic. The author discusses various illusions presented by Röntgen rays, leading apparently to a distinction between Röntgen rays and light; but these find their parallel in the behaviour of ordinary penumbræ from sources of some size and of particular forms. Röntgen rays travel in straight lines, subject to scattering which bears no relation to the diffusion or reflexion of light on the surface of the body traversed. Apparent maxima and minima of Röntgen illumination through slits or past obstacles are closely analogous to similar peculiarities in ordinary light and are not due to diffraction, but may be traced to peculiarities of the photographic plate and of the retina of the eye. On the photographic plate and the retina the impression is greatest or least where the curve showing the true variation of illumination presents a sharp bend or where its tangent is steep. The cause of this lies in the influence of neighbouring parts of the sensitive film or of the retina, this influence being that of a secondary destructive or reversing action, possibly due to secondary rays excited by the impinging Röntgen rays. In the case of the plate this action may tell upon the formation of the latent image, or possibly upon the process of development: more probably the former, for, if so, this would go far towards pointing out an explanation of ordinary reversal under over-exposure, with its waning maxima and minima, and ultimate neutral state. This would follow from (1) a positive action proportional to the time, and (2) a negative action, the change of which is proportional to the resultant effect at a given interval of time prior to the instant of observation. The apparent peculiarities in the rectilinear propagation of Röntgen rays all disappear: the course of Röntgen rays is the same as that of light rays. At the same time we have no diffraction, refaction, reflexion, or regular polarisation. All this is, however, brought into harmony by the Stokes and J. J. Thomson theory, with the additional observation that with ordinary light refraction would be impossible if the wave-lengths were less than twice the distance between the particles of the prism. It is also impossible where the train of disturbance of the ether produced by molecule-impacts (Stokes) dies out in less than twice the same distance; and the result is the same whether for transverse or longitudinal ether disturbance (see the author, Journ. de Physique, 3. ser. t. ix., p. 188, 1900). The same short wave-lengths or disturbance trains also necessarily act in an ordinary pure homogeneous medium as ordinary light does in a troubled medium; which explains the scattering of Röntgen rays. A. D.

1277. *Effect of Becquerel and Röntgen Rays on the Eye.* **F. Himstedt** and **W. A. Nagel.** (Ann. d. Physik, 4. 3. pp. 537–552, March, 1901. Aus den Ber. d. Naturf. Gesellsch. in Freiburg i. B. XI. p. 139, 1901.)—Becquerel rays excite fluorescence in all parts of the eye. Consequently when the rays pass through different shaped openings in a lead plate, the eye is unable to distinguish the different shapes of these openings. When using ultra-violet rays the authors could not succeed in entirely freeing these from visible rays, and were forced to conclude that ultra-violet rays also produce fluorescence in the eye. Under Röntgen rays no fluorescence could be observed in the different parts of the eye, and it is doubtful if the retina fluoresces to any perceptible extent. It may be said, however, that perception of Röntgen, Becquerel and ultra-violet radiation is chiefly, if not entirely, by means of the rods of the retina, but whether by direct action or indirectly by fluorescence could not be decided.

A purely objective proof of the action of Röntgen rays on the eye was demonstrated by using the current from a frog's eye. The back and front of the eyeball of a frog, which had been kept in the dark, are connected by unpolarisable electrodes with the galvanometer circuit of a potentiometer; a current flows along the circuit from the front to the back of the eye with an e.m.f. of from 0·0056 to 0·0172 volt. When light or Röntgen rays fall on the eye the e.m.f. increases for from 10 to 60 seconds and then decreases. On stopping the action of the light or Röntgen rays there is a momentary increase followed by a quick decrease of the e.m.f. For eight frog's eyes tested the increase in e.m.f. caused by 30 seconds' exposure to Röntgen rays was, on the average, one-third of that caused by 10 seconds' exposure to a 16-c.p. glow-lamp. For the eight eyes the e.m.f. increase due to the glow-lamp had respective values varying from 0·00035 volt to 0·0022 volt.

G. E. A.

1278. *Secondary Radio-Activity.* **H. Becquerel.** (Comptes Rendus, 132. pp. 734–739, March 25, 1901.)—The author has carried out further researches on the secondary rays produced by the impact of radium rays. [See Abstract No. 1077 (1901).] He finds that the glass supporting the gelatine films plays an important part in the phenomena described. He proceeds to explain certain peculiarities shown by radiograms on the basis of the secondary rays.

E. E. F.

1279. *Secondary Rays Derived from Röntgen Rays.* **G. Sagnac.** (Annal. Chim. Phys. 22. pp. 493–563, April, 1901.)—A summary of extant knowledge, with some additional researches. When Röntgen rays are sent through any substance that substance emits secondary rays in every direction from every particle within a certain depth. These secondary rays resemble Röntgen rays in (1) rectilinear propagation, (2) production in a similar way of tertiary rays, (3) action upon photographic plates, (4) illumination of barium platino-cyanide screens, (5) discharge of electrified conductors. The penetrating powers of the secondary rays vary with (1) the nature of the impinging Röntgen rays, (2) the chemical constitution, but not appreciably the physical condition of the substance from which they are developed. In heavy metals (Cu, Zn, Fe, Ni, Sn, Pt, Pb) or substances containing these, the secondary rays are less penetrating than the originating Röntgen rays and can only emerge from layers very near a free surface, particularly the surface of impact or of exit, of the Röntgen rays. The phenomenon is thus not one of selective diffusion; there is a true transformation into less penetrating rays. The tertiary rays are still less penetrating than the secondary. The bundles of Röntgen rays hitherto employed act as mixtures of radiations differing greatly in penetrative power; and secondary rays, even when produced by simple substances, are extremely complex, particularly when heavy metals or their compounds are used. In the order in which the above metals have been named, the later in the series the greater the transformation in the production of secondary rays, and the more absorbable and the more active the secondary rays produced under the impact of Röntgen rays from one and the same source; and in all secondary rays the more active these are the more easily are they absorbed. For Fe, Ni, Sn, Pt, Pb, the most active (electricity-discharging or radiographic) secondary rays are absorbed by layers of air down to 1 cm., 1 mm., or even less, while the Röntgen rays which give rise to these will traverse much greater thicknesses of air. A. D.

REFERENCES.

1280. *Retinal Phenomena.* **A. Charpentier.** (International Physical Congress at Paris, Report, 3. pp. 523–546, 1900.)—The author deals with the following questions: (1) What are the objective phenomena produced by light upon the retina? (2) What are the subjective phenomena, or sensations produced by light as it varies in intensity, colour, form, position or duration? (3) If, as is often the case, the two preceding questions cannot be investigated upon the same subjects (man alone being available for the second), is it possible to establish their similarity? The article is a *résumé* of the work done by various physicists and physiologists of modern years who have studied this department of science. W. C. O.

1281. *Representation of Substances which Rotate the Plane of Polarisation.* **A. Garbasso.** (Archives Néerlandaises. 5. pp. 524–528, 1900.)—From the suggestion of Bose's experiments on the passage of electric waves through a rope of jute fibres, the author constructs a set of electromagnetic equations representing those optical media which rotate the plane of polarisation. The results obtained are in accord with Lorentz's equations. E. H. B.

1282. *Dispersion of Ultra-violet Rays in Rock-Salt and Sylvin.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 3. 4. pp. 31–35, 1901.)—The refractive indices of prisms of rock-salt and sylvin are measured for a number of ultra-violet spectral lines in the spark spectra of Al, Au, Cd, Pb; and for a number of lines in the visible spectra of H, Hg, K, Li, and Na. The results are tabulated in the paper, the refractive indices being given for forty-one different wave-lengths between the values 185 and 769 $\mu\mu$, twenty-five being in the ultra-violet and sixteen in the visible spectrum. J. B. H.

1283. *A Simple Spectrometer and the Measurement of Refractive Indices.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 3. 2. pp. 10–17, 1901.)—The various ways of using a spectrometer to measure the angles and refractive indices of prisms are here reviewed and compared as to their applicability and accuracy in different circumstances. J. B. H.

1284. *Distribution of Energy in the Spectrum.* **M. Planck.** (Ann. d. Physik, 4. 3. pp. 553–563, March, 1901.)—The author presents the arguments and conclusions of two previous papers in a different form and in fuller detail. [See Abstracts Nos. 507 and 508 (1901).] W. E. T.

1285. *Spectra of Coloured Glasses.* **C. Grebe.** (Zeitschr. Instrumentenk. 21. pp. 101–105, April, 1901.)—This paper contains spectrum photographs on Cadett spectrum plates taken through the coloured glasses mentioned in Abstract No. 1267 (1901). Thirty-five photographs are reproduced for the different glasses in different thicknesses, and for combinations suitable for three-colour photography and other purposes. G. H. B.

HEAT.

1286. *Latent Heat of Evaporation of Liquids.* **H. Crompton.** (Chem. Soc., Proc. 17. pp. 61–63, April 10, 1901.)—On the assumption that it would be possible at constant temperature and by compression alone to reduce a saturated vapour from the volume V_0 to the volume v_0 which the liquid it forms would normally occupy, without any change in state occurring, and with the substance continuing to obey the gas law, the author deduces the expression $2RT \log V_0/v_0$ for the latent heat of evaporation. By means of the observations of Cailletet and Mathias on carbon dioxide, nitrous oxide, and sulphur dioxide he is able to test the formula for fairly wide variations of temperature and pressure with satisfactory results. In general the calculated values are from 5 to 10 per cent. too high, perhaps because the saturated vapour at the boiling-point is not a perfect gas, and has a slightly higher density than that corresponding to the normal molecular weight. With a few associating liquids the calculated values are slightly too low. The author points out that if liquids were truly comparable at the boiling-point, the ratio V_0/v_0 would be the same for all liquids at this point, and then Trouton's law, according to the above expression, would hold absolutely. W. E. T.

1287. *Tempering of Thermometers.* **O. Hecker.** (Zeitschr. Instrumentenk., Beib. 5. pp. 41–42, March 1, 1901.)—A convenient method of tempering thermometers, in order to prevent error due to change in the fixed points, is described, and its advantages pointed out. The thermometer is contained in a vessel round which a coil of platinum wire is wound, which can be maintained at a high temperature by means of an electric current. By means of clockwork a resistance is gradually inserted so that the temperature gradually falls and a slow cooling of the thermometer ensues. Details are given of the apparatus used by the author. W. E. T.

1288. *Boiling-point of Liquid Hydrogen.* **J. Dewar.** (Roy. Soc., Proc. 68. pp. 44–54, March 5, 1901.)—A platinum-resistance thermometer had given the value —238·4° C., but as this depended on an empirical ratio between temperature and resistance, and involved a large interpolation, it became necessary to have recourse to the gas thermometer. The constant-volume form was found most suitable, using Chappuis's formula; the apparatus is figured and described. The gases used were O_2 helium, CO_2, and H_2, electrolytic and from palladium. It was proved that either a simple or compound gas, at an initial pressure somewhat less that 1 atmosphere, could be relied on to determine temperatures down to its own boiling-point, and that the initial pressure should be rather high than low. Helium had the advantage of being less condensible than hydrogen. It was obtained from the King's Well at Bath, and when purified was free from other gas except 7·4 per cent. of neon, according to refractivity measurements. Tables are given of the various determinations and of the corrections. The average values found for the boiling-points were: CO_2 — 78·2°; O_2 — 182·5°; H_2 — 252·5°; neon — 239°; air 189·6°; solid hydrogen (from palladium, 30 to 40 mm.) 257·2°. S. R.

1289. *Calibration of Thermo-electric Elements.* **E. L. Nichols.** (Archives Néerlandaises, 5. pp. 339–347, 1900.)—A description is given of a quick method of calibrating elements formed of platinum and platinum alloys. This calibration is needed as the value of the e.m.f. found in particular cases depends on the special specimens of metal used. The melting-points of certain metals are known and are used as reference points. The author uses a specially arranged acetylene flame, in which a very constant and high temperature can be obtained at definite points by suitable adjustments. In this flame the various metals with reference melting-points are fused. By means of this arrangement the use of an air thermometer is avoided, and the long and laborious procedure of fusing metals in considerable masses within a furnace is not necessary; and, moreover, the mass of metal required is very much smaller, and the action on the junction caused by fumes is avoided. The accuracy of the method described is claimed by the writer of the paper to be equal to that of other known methods of calibration. J. J. S.

1290. *Temperature of Highly Heated Bodies by Photometric and Bolometric Methods.* **O. Lummer** and **E. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 3. 4. pp. 36–46, 1901.)—The authors have in a former paper described their experiments, comparing the radiation of the ideal black body with that of a polished platinum surface by means of a spectrobolometer. These experiments proved that the equation $\lambda_m T = \text{const.}$ holds for the platinum surface as well as for the black body, the constant, however, being 2,630 for the platinum surface, and 2,940 for the black body. If we know λ_m for any other radiating body, the above equation enables us to fix its temperature at least between certain limits, the temperatures of the platinum surface and of the black body which correspond to the given value of λ_m. The limits thus obtained are wide, being about 200° C. at about 2,000° C. To reduce those limits one would require to know the relative blackness of the radiating body, but in many cases they can be reduced by a purely photometric method. Wanner used this method to determine the temperature of the electric arc. He obtained the isochromatic energy-temperature curves for the visible spectrum and extrapolated them, assuming Wien's formula to hold. This assumption was justified by Paschen's spectro-bolometric experiments, but the later experiments by the present authors have shown that Planck's formula satisfies the conditions much better—

$$E = \frac{C\lambda^{-5}}{e^{\frac{c}{\lambda T}} - 1}$$

This formula is not (like Wien's) applicable only within certain limits; it is deduced from the Boltzmann-Wien law,

$$E = T^5 \phi(\lambda T),$$

which has been established both theoretically and experimentally (Wien's formula holds only if $\lambda T < 3{,}000$).

The authors have photometrically determined the isochromatic curves in the visible spectrum of their electrically incandesced "*black body*." These curves give the mean value of c in the above equation as 14,580, while the value obtained from the spectro-bolometric experiments was 14,600. Wien's equation would give $c = 14{,}700$, so that there is little difference between the two equations when $\lambda T < 3{,}000$, which is the case for the visible spectrum at all earthly temperatures.

Similar curves are also determined for an incandescent platinum cylinder having a thermoelectric junction inside to measure the temperature. A comparison is thus obtained between the visible radiation of incandescent platinum and that of the ideal black body. The difference of temperature between the two for equal radiation is about 40° at 1,100° C. and about 110° at 1,876° C. The error in assuming the radiation of any other body (say an incandescent lamp) to be that of the ideal black body and calculating its temperature accordingly, would be less than in the case of incandescent platinum ; and if the mean of the temperatures obtained photometrically and bolometrically be taken, a still closer approximation to the real temperature can be obtained. [See further Abstract No. 1045 (1900).] J. B. H.

1291. *Molecular Attraction in Slightly Compressed Gases.* **M. Reinganum.** (Archives Néerlandaises, 5. pp. 574–582, 1900.)—On van der Waals' theory the forces between the molecules in the interior of a gas compensate each other, but this is not likely for small densities, and, taking into account the planetary influence of the molecules on each other, the author has found that, if $\chi(\sigma)$ denotes the maximum work done by the attractive forces during the approach of two molecules, the usual expression, $\frac{1}{3}\pi n\sigma^3u^2/v$, for the virial of the repulsive forces exerted during an encounter, assumed as instantaneous, should be altered in the ratio $exp\ (3\chi/mu^2)$ or $exp\ (c/T)$, where c is a constant proportional to χ and independent of the absolute temperature T, but like χ decreasing with v. The author now gives reasons for assuming that the virial of the attractive forces is $-\frac{3}{2}U$, where U denotes the heat required to expand unit mass isothermally from v to infinity: hence Clausius' virial-equation becomes—

$$\tfrac{1}{2}u^2 = \tfrac{3}{2}pv + \tfrac{3}{2}U - \tfrac{1}{3}\pi n\sigma^3u^2v^{-1}e^{c/T},$$

whence, if, as usual, $b \equiv \frac{2}{3}\pi n\sigma^3$, $RT \equiv \frac{1}{3}u^2$,

$$pv + U = RT(1 + bv^{-1}e^{c/T}).$$

The reasoning by which the above value of the virial of the attractive forces is obtained shows these forces to be inversely as the fourth power of the distance, and gives—

$$U = Rbcv^{-1}\left\{\log(c/T) + c/T + (c/T)^2/1.2^2 + (c/T)^3/1.2.3^2 + \ldots\right\},$$

and for the internal pressure, $p_i \equiv U/v$, we have—

$$\partial p_i/\partial T = -Rbce^{c/T}/Tv^2.$$ R. E. B.

1292. *Reduced Gibbs' Surface.* **H. Kamerlingh Onnes.** (Archives Néerlandaises, 5. pp. 665–678, 1900.)—Reckoning the energy and entropy of a fluid by their variations ε,η from their values at the critical point, given by P, V, T, and considering a fluid whose changes of pressure and temperature are proportional when isometric, so that with "reduced" co-ordinates

$$\pi = \mathfrak{A}\tau + \mathfrak{B},$$

where $\mathfrak{A}$ and $\mathfrak{B}$ are functions of the reduced volume ω, and taking the isometric specific heat k to be constant, we have (with slightly simplified notation)—

$$E \equiv \varepsilon/PV = -\int_1^\omega \mathfrak{B}d\omega + S(\tau - 1),$$
$$H = \eta T/PV = \int_1^\omega \mathfrak{A}d\omega + S\log\tau,$$

where

$$S \equiv \kappa T/PV = RT/PV(\kappa - 1),$$

whence on the thermodynamic surface with ω, E, H for co-ordinate axes

the *shape* of all the isothermals is the same, being that of the curve given by—

$$E_1 = -\int_1^\omega \mathfrak{B} d\omega, \quad H_1 = \int_1^\omega \mathfrak{A} d\omega,$$

and their respective *positions* are obtained by sliding this curve parallel to itself along the director-curve

$$E_2 = S(\tau - 1), \quad H_2 = S \log \tau.$$

On van der Waals' theory $\mathfrak{A} \equiv 8/(3\omega - 1)$, $\mathfrak{B} \equiv -3/\omega^2$, $S = 8/3(\kappa - 1)$; the author has constructed three models of the surface for this case corresponding to values of κ equal to 1·66, 1·20, 1·06, on which he has traced the connode or so-called "boundary-curve" and the isothermals for $\tau = 1$, 0·9, 0·8, 0·5. These models exhibit the law of the straight diameter to quite low temperatures, and also a parabolic relation between the saturation vapour densities and τ, as well as van der Waals' empirical relation,

$$\log \pi = 3{\cdot}4(1 - \tau^{-1}),$$

for saturation pressures.

Consideration of the projections of the connodes on the ωH- and EH-co-ordinate planes shows that for $\kappa < 1{\cdot}195$ the specific heat of a saturated vapour is never positive, that for $\kappa = 1{\cdot}195$ it is approximately 0 for values of τ between about 0·87 and 0·57, that when $\kappa < 1{\cdot}195$ it has two points of inversion until some value of κ greater than 1·06 below which there is one point of inversion only.

If π is not of the above assumed form, this method can still be employed with due *correction* of the E_1H_1- and E_2H_2- curves, since the assumption holds good as a first approximation. R. E. B.

1293. *Derivatives of the Thermodynamic Potential according to* T *and* p *in the case of Compound Substances.* **J. J. van Laar.** (Archives Néerlandaises, 5. pp. 484–496, 1900.)—The thermodynamic potential of Gibbs and Dickens being denoted by Z, Planck's heat function, Ψ, is—

$$-Z/T = S - \frac{1}{T}(E + pV),$$

in the usual notation. We have also—

$$dE = TdS - pdV - \Sigma(\mu_1, dn_1).$$

Here μ_1 μ_2, &c., are the so-called molecular thermodynamic potentials of the components, the numbers of the molecules being n_1, n_2, &c.; writing ψ_1, ψ_2, &c., for $-\mu_1/T_1 - \mu_2/T$, &c., we have—

$$\psi_1 = \frac{\partial \Psi}{\partial n_1}, \quad \psi_2 = \frac{\partial \Psi}{\partial n_2}, \text{ &c.}, \quad \frac{\partial \Psi}{\partial T} = \frac{1}{T^2}(E + pV), \quad \frac{\partial \Psi}{\partial p} = -\frac{V}{T}.$$

These relations are discussed in the present paper.

A solution of salt in water is considered. In electrolysis there will be dissociation, some of the water molecules becoming single instead of double. The molecules of the salt are said to be dissociated electrically, the undissociated molecules being neutral, the others resolved into positive and negative ions. The *degrees of dissociation*, that is the proportion of the molecules of a given class which are dissociated, are for the salt α, and for the water β, so that water consists of $(1 - \beta)n_1$ double molecules, $2\beta n_1$ single,

and the salt now consists of $(1-\alpha)n_2$ neutral molecules, and of $\nu\alpha n_2$ positive and the same number of negative ions. Here ν is the number of ions into which a neutral salt molecule is resolved. If now we use the symbol d to denote total differentiation, instead of $\frac{\partial\Psi}{\partial n_1}=\psi_1$, &c., we have—

$$\frac{d\Psi}{dn_1}=\frac{\partial\Psi}{\partial n_1}+\frac{\partial\Psi}{\partial\alpha}\frac{d\alpha}{dn_1}+\ldots=\psi_1, \text{ \&c.}$$

The author obtains as the general equations expressing the changes due to any reaction, in which $\Sigma(\nu_1\psi_1)=0$

$$\Sigma\left(\nu_1\frac{d\psi_1}{dT}\right)=\frac{1}{T^2}(\Delta E+p\Delta V),$$

$$\Sigma\left(\nu_1\frac{d\psi_1}{dp}\right)=-\frac{\Delta V}{T},$$

and $\Delta E+p\Delta V$, or Q, is the absorbed molecular heat. These relations were first given by the author in 1892 for a less general case. The distinctive character of the present paper is the use of the total differentiation.

The author next discusses equlibrium of dissociation. If $\overset{\circ}{\psi}_1, \overset{\circ}{\psi}_2$, &c., relate to the undissociated parts of the compound substances, so that—

$$\psi_1=\overset{\circ}{\psi}_1+\alpha\,(-\overset{\circ}{\psi}_1+\overset{+\,+}{\nu}\overset{+}{\psi}_1+\overset{-\,-}{\nu}\overset{-}{\psi}).$$

When there is equilibrium, the factor within the bracket is zero, and $\psi_1=\overset{\circ}{\psi}_1$, and this relation continues in the total differentiation according to T and p, and now the equations used are—

$$\Sigma(\nu_1\overset{\circ}{\psi}_1)=0$$

and—

$$\Sigma\left(\nu_1\frac{d\overset{\circ}{\psi}_1}{dt}\right)=\frac{Q}{T^2}, \quad \Sigma\left(\nu_1\frac{d\overset{\circ}{\psi}_1}{dp}\right)=-\frac{\Delta V}{T}.$$

Next, if $\overset{\circ}{\psi}_1=\overset{\circ}{\psi}'_1-R\log\overset{\circ}{c}_1$, &c., we find instead of $\Sigma(\nu_1\overset{\circ}{\psi}_1)=0$,

$$\Sigma(\nu_1\overset{\circ}{\psi}'_1)-R\Sigma(\nu\log\overset{\circ}{c}_1).$$

Hence known relations can be deduced. He points out an error frequently made in using ψ' and ψ'_0 in these formulæ.

In the last section he shows how these relations may be applied to the solution of problems, for instance, in electrolysis, the relation between the heat of solution and solubility. S. H. B.

1294. *Van der Waals' ψ Surface.* **C. M. A. Hartman.** (Archives Néerlandaises, 5. pp. 636–641, 1900.)—The author applies the graphical method of K. Onnes (Zittingsversl. Kon. Akad. v. Wet. te Amsterdam, June, 1900, p. 199) to the condensation phenomena, which he has observed in his investigation of the form of the connodal curves for mixtures of methyl chloride and carbonic acid at 9·5° C. He wished to use the same equation and constants as those used for the representation of Kuenen's experiments on mixtures of

these substances at 100° C., but in order to obtain from them satisfactory values of the vapour pressures of the pure substances he used the expression—

$$a_x = \frac{K_x}{T_{KV}} e^{\frac{T_{KV} - T}{T_{KA}}}$$

for the molecular attraction, K_x being the function used for the experiments at 100° C. ; at the critical temperature T_{KV} of the mixture the equations become identical. The values of the constants used and the results obtained are given for five mixtures, along with a picture of a model of the surface.

W. E. T.

REFERENCES.

1295. *Kinetic Theory of Gases.* **S. H. Burbury.** (Ann. d. Physik, 4. 3. pp. 646–647, March, 1901.)—A mathematical reply to the criticism of G. Zemplén [Abstract No. 828 (1901)] in which the author maintains his own position. E. H. B.

1296. *Measurements of Temperature.* **P. Chappuis.** (International Physical Congress at Paris, Report, 1. pp. 131–147, 1900.)—In this report a brief summary is given of the systematic researches which have been undertaken in order to reduce to one well-defined scale the various arbitrary measurements of temperature. J. J. S.

1297. *Mechanical Equivalent of Heat.* **J. S. Ames.** (International Physical Congress at Paris, Report, 1. pp. 178–213 ; **E. H. Griffiths,** pp. 214–228, 1900.)—A valuable historical summary is given of the methods employed and the results obtained in the various determinations of the mechanical equivalent of heat. An appendix to the report is written by E. H. Griffiths in which he gives an account of his own work and that of Rowland and Barnes on the *specific heat of water.*

J. J. S.

SOUND.

1298. *Resonance of Air Columns.* **V. Mahillon.** (Phys. Rev. 12. pp. 193-219, April, 1901.)—Air columns of conical, trunco-conical, and cylindrical forms were experimented with in the form of open and partially closed pipes.

The open pipes were made to sound by blowing transversely across the end.

A series of tubes were constructed varying in diameter from 0 to 30 mm. at one end, and having a common diameter of 15 mm. at the other. Each tube had a length of about 24 cm. The following facts were observed: (1) The pitch is the same whether the blast be directed across the large or the small end. (2) The length of the tube is in each case that of a single wave less $\frac{3}{4}$ of the mean diameter of the tube. (3) The harmonies are proportional to the fundamental sound of the tube.

The tube having diameter 0 at one end and 15 at the other, strangely enough acts as an open pipe, contrary to theory, its length for a given sound being equal to the single wave-length of that sound; and it gives the series of harmonies 1, 2, 3, 4, just like an open pipe. With partially closed pipes the tone is lowered by the closing, the influence which the closing exerts being inversely proportional to the length of the pipe.

In the transverse flute, where the air is made to vibrate by blowing through a hole in the side of the instrument, the length of the tube beyond the hole towards the closed end does not affect the fundamental tone, but does affect the harmonies; hence the length of this part of the flute should never be altered in tuning it, as it acts upon the harmonies which bear a correct ratio to the fundamental tone and throws them out.

In the closed columns formed from the series of cylindrical pipes described above, various methods of producing vibrations were adopted: (A) Directing a blast of air across the open end. (B) Fitting a mouthpiece. (C) By a reed.

The tubes with a small opening at the smaller end, or no opening at all, when caused to vibrate by blowing across the larger end, give, as explained above, the same note as if they were open tubes of the same mean diameter.

The trunco-conical tubes vary in the fundamental note which they give according to the end from which they are blown, but the harmonics remain the same. Trunco-conical tubes seem to act like conical tubes more or less, but their pitch becomes lower as compared with the open tube in proportion to the diameter of the truncated part, where the tube is closed. The diameter of the open end must be at least four times that of the closed end for a tube of trunco-conical form to sound the octave. The fact that the cylindrical tube drops a full octave by stopping one end leaves one to suppose that the phenomenon of the trunco-conical and conical tubes of certain forms resounding like open tubes is due to the reflection of the vibration from the side.

In mouthpiece instruments with cylindrical tubes the air vibrates as in stopped pipe, giving only the odd harmonies. If the lower part of the tube be expanded the fundamental tone rises, as do also the harmonies, approaching gradually the series 1, 2, 3, 4. If the vibration is produced in a reed-pipe by means of a piece of natural reed the flexibility of it is so great that it can set in vibration very different columns of air; the metallic reed requires the column to be almost in unison with it. W. C. O.

1299. *Velocity of Propagation of Sound.* **J. Violle.** (International Physical Congress at Paris, Report, 1. pp. 228–246. Appendix by **M. Brillouin,** pp. 246–250, 1900.)—The different methods adopted to determine experimentally the velocity of sound are discussed, and the values obtained, including that found by the author of the report, are given. The author concludes that the normal velocity in dry air at zero differs very little indeed from 33,136 cm. per second.

The appendix to the report gives a mathematical investigation of the theory of the propagation of sound in a large tube. J. J. S.

1300. *Nature of Vowels.* **E. W. Scripture.** (Amer. Journ. Sci. 11. pp. 302–309, April, 1901.)—The speech curves are obtained by slowly rotating a gramophone plate (one revolution in five hours) and causing a needle to follow the written record, its movements being magnified by means of levers, and finally recorded on smoked paper.

Figures are given showing the form of the vibration for the different vowel sounds. The curve for the vowel "I" shows a series of groups of vibrations similar in form, each group having the form characteristic of a vibration initiated by a blow and dying away by friction. These groups show increasing amplitude, and occur with steadily decreasing intervals. The vibrations evidently result from a series of blows with increasing strength at steadily decreasing intervals.

The fundamental tone of the cord shows as a series of impulses rising from frequency 59 per second to 192 per second; resonance tones, 294, 769, and higher tones are also present.

The combined rise in pitch and amplitude found in "A" is seen also in all curves of "I" which have been examined at the early part of the sound. In the case of "I," however, the vibration changes at the end, showing two vibrations, one slightly stronger than the other, of frequency 192 each, finally lengthening to 82 each.

In the "E" sound, as pronounced in "said," the pitch of the cord tone is nearly constant at 139.

The following conclusions are drawn from a study of the curves.

1. The movement of the air in the mouth cavity is a free vibration and not a forced one, for the mouth tone, as shown by the curve, is constant even while the cord tone is changing; there is therefore no relation between the adjustment of the size of the mouth cavity and the tension of the vocal cords. The mouth tone is not a harmonic of the cord tone.

2. The cord movements, in the formation of the vowel sounds, are of the nature of explosive openings, and not vibratory, as in most musical instruments; hence the impossibility which has been found of producing vowel sounds by the combination of simple tones.

Examination of the anatomical structure of the cords also bears out this theory. They are evidently much more suited for the emission of a series of puffs than to vibrate as stretched membranes. W. C. O.

1301. *Production of Vowel Sounds.* **R. Marage.** (Soc. Franç. Phys., Séances, 2. pp. 109–147, 1900.)—The author gives further analyses of vowel sounds [see Abstract No. 1450 (1900)] by various graphic methods. He also takes moulds of the human vocal organs as posed for the production of various vowels, and reproduces the various vowel sounds with their aid.

E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1302. *Distribution of Electricity on an Ellipsoid.* **H. Dörrie.** (Ann. d. Physik, 4. 3. pp. 638–641, March, 1901.)—A mathematical article showing that, if a sphere with uniform distribution of electricity be deformed into an ellipsoid, each element of surface retaining its charge without increase or diminution during the deformation, the resulting distribution of electricity is that which is in equilibrium. The ellipsoidal distribution may be expressed quantitatively as follows: Let O be any point on an ellipsoid of semi-axes a, b, and c charged with M units of electricity, and let p denote the perpendicular from the centre of the ellipsoid to the tangent plane at O, then the surface density at O has the value $Mp/4\pi abc$. E. H. B.

1303. *Fundamental Equations of Electrodynamics and Crémieu's Experiment.* **H. C. Pocklington.** (Phil. Mag. 1. pp. 325–330, March, 1901.)—The equations of the electromagnetic field are deduced in the Hertz form from the results of experiments combined with four assumptions, and are then used to show that a moving charge produces a magnetic field, the argument failing in the case of the charge being on an infinitely long body. The equation in the case of Crémieu's experiment, to produce an induced current in a coil round a rotating disc by suddenly charging the disc, cannot be integrated out, and the author does not consider the hitherto accepted equations of the magnetic field as affected by Crémieu's experiment. G. E. A.

1304. *Long-distance Telephone Lines.* **E. F. Roeber.** (Elect. World and Engineer, 37. pp. 440–441, March 16; 477–479, March 23; and 510–513, March 30, 1901.)—The chief object of this set of articles is to develop the mathematical theory of the Thompson system and the Reed system of line construction for long-distance telegraphy and telephony by methods similar to those adopted by Pupin for his own system [see Abstract No. 2122 (1900)]. M. I. Pupin's system has inductances equally spaced along the line as suggested by Heaviside. The system due to S. P. Thompson is characterised by the insertion of bridges or shunts of appropriate resistance and inductance across the line at equal distances along it. The third system, due to C. J. Reed, consists in dividing the whole circuit into a series of circuits, connected together by transformers in such a way that the secondary of any transformer forms a closed circuit with the primary of the next transformer. Or, we may say, the line on the Reed system is divided into a number of equal parts connected together by mutual inductance.

The results of the mathematical discussion of these systems may be stated briefly as follows: A loaded conductor of the Pupin type behaves like a uniform conductor with greater inductance per unit length than the original unloaded conductor; a loaded conductor of the Thompson type behaves like a uniform conductor with smaller resistance per unit length than the original unloaded conductor; whereas in a loaded conductor of the Reed type both these beneficial effects may be combined. E. H. B.

DISCHARGE AND OSCILLATIONS.

1305. *Characteristic Curves for Electric Discharges in Rarefied Gases.* **E. Riecke.** (Ann. d. Physik, 4. 3. pp. 592–616, March, 1901.)—When an electric current passes through a gas in a Geissler tube, the relation between potential difference and current is much more complicated than that given by Ohm's law. For a given tube this relation can be exhibited in the form of a "characteristic curve." The tube used by the author was a sphere of 5·9 cm. radius. Tables and curves are given illustrating the effects of magnetic action and change of pressure on the form of the characteristics. D. E. J.

1306. *The Delay of Discharge through Magnetic Force.* **J. Stark.** (Phys. Zeitschr. 2. pp. 382–383, March 30, 1901.)—It has been shown by Warburg that if a transverse magnetic field be created in the space between two electrodes in a rarefied gas, and if now a gradually increasing potential difference be established between them, then the presence of the field delays, in some cases several minutes, the passage of the luminous discharge. J. J. Thomson and Warburg explain this by supposing that there are in the gas, previous to the visible discharge, a number of ions; by the action of the electric field this number is gradually increased, thereby increasing the conductivity of the gas, until finally the current they carry is sufficient to render the discharge luminous. The magnetic field, on the other hand, tends to displace the moving ions in a direction at right angles to that joining the electrodes, thereby diminishing the conductivity. Stark considers that the ions are made to move in spiral paths and so move very little towards the opposite electrodes. The effect is found to be much greater when the anode is removed some distance and the kathode is placed in the magnetic field; a diminution of pressure brings about the same result. This arises from the fact that the negative ions move much quicker than the positive ones, and the less the pressure the greater their velocity. R. S. W.

1307. *Silent Electric Discharge.* **S. Leduc.** (Comptes Rendus, 132. pp. 542–543, March 4, 1901.)—The author describes some further remarkable properties of the silent electric discharge, or "electric effluvium," whose physical and chemical effects he has latterly been investigating. He produces it by rapidly charging and discharging a condenser consisting of a metallic sphere on the one hand, and a sheet of aluminium with a central perforation on the other hand, separated by a plate of glass or celluloid. The central portion of the plate is on both its faces the origin of violet and ultra-violet rays, which can be concentrated by a quartz lens. These rays produce an intense fluorescence on a platino-cyanide screen without concentrating the beam, and photographic effects are obtained which surpass in intensity those produced by sunlight. The rays are particularly valuable for Finsen's treatment of anæmic tissues. These are compressed by means of a quartz plate contained in an ebonite frame, which directly adjoins the aluminium sheet forming one armature of the condenser. The diseased tissue is thus exposed to rays which have only to traverse a thin plate of quartz. The apparatus may be worked with an induction coil or an influence machine. E. E. F.

1308. *Velocity of Ions drawn from the Electric Arc.* **C. D. Child.** (Phys. Rev. 12. pp. 137–150, March, 1901.)—It has been previously found [Abstract No. 847 (1901)] that the velocity of the positive ions drawn from the flame of a Bunsen burner is slightly less than that of the negative ions, viz., 2·2 cm. per

sec. for the + ions and 2·6 cm. per sec. for the — ions for a potential gradient of 1 volt per cm. The same method has now been applied to the ions drawn from an arc, with the result that the positive ions are found to move faster than the negative ions in the ratio of about 2 to 1. This effect is not due to the ultra-violet light of the arc, and is reversed in the case of an arc between metals. A similar effect is obtained with carbon heated in an oxyhydrogen flame, but at lower temperatures or with no carbon in the flame the phenomena resemble those obtained with a Bunsen burner. T. M. L.

1309. *Number of Ions in Air Saturated by Phosphorus Emanations.* **C. Barus.** (Science, 13. pp. 501–503, March 29, 1901.)—A short theoretical discussion based on earlier experiments [see Abstract No. 1772 (1900)]. These experiments show that when ionised air is passed through a charged tubular condenser, only an insignificant number of the ions take part in the electric current radially through the condenser, and the author gives a mathematical analysis to show that the phenomenon of leakage in a plate condenser may be fully explained by taking account of the ions which wander *laterally* out of the field of force. W. C. H.

1310. *Rotations Produced by Electric Sparks.* **A. G. Dell.** (Elect. World and Engineer, 37. pp. 513–515, March 30, 1901.)—A mica disc is coated with shellac and rotates in a horizontal plane. Spark discharges, of a maximum length of $\frac{3}{4}$ inch, pass under the disc on one side. When the disc is made sensitive enough as regards freedom of rotation and balancing, it starts to rotate from the + to the — pole. If started in the opposite direction it also continues to rotate in that direction without reversal. When moisture is carefully removed from the disc, the direction of rotation becomes more and more arbitrary. Heat reduces the velocity of rotation, and to some extent increases the starting velocity required to send it in the direction from — to +. When, instead of using jewelled bearings, the axle of the wheel is magnetised and suspended by a magnet pole, it is possible to obtain rotations from a $1\frac{1}{2}$-inch spark with the disc raised $\frac{3}{4}$ inch above the spark path. On making the disc into a small condenser a curious phenomenon was observed by the author. The disc started in the direction +, stopped, started again several times, then suddenly started in the opposite direction, reversed again, and finally came to a total stop. E. E. F.

1311. *Colouration Produced by Radiation.* **E. Goldstein.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 10. pp. 222–229, Feb. 21, 1901.)—It is well known that alkali salts show various colours when exposed to the action of kathode rays. Goldstein shows that other salts may also become coloured. These colours may be divided into two classes: (1) Those which disappear rapidly when exposed to daylight; (2) Those which do not disappear under these conditions, or at least disappear very slowly. The colours of the first class are produced by exposing the salt to kathode rays for a short time, the temperature being that of the room. Heating the salt generally causes their disappearance. Those in class (2) only appear when the substance is heated, the rays impinging at the same time, daylight itself not causing their disappearance except after some months. The same substance may therefore give colours of each class. The rays themselves may be used as the heater. Both colourations can be produced in gases at a pressure as high as 50 mm. although the time then required is considerably longer than for lower pressures. The positive light, ultra-violet light, and radio-active substances are

all more or less efficient agents in their production. The author compares the various effects produced by kathode rays, "entladungstrahlen," and the radiation from radio-active substances with those produced by ultra-violet light, and arrives at the conclusion that they are all due to ultra-violet light of very short wave-length. R. S. W.

1312. *Coherer.* **T. Tommasina.** (Comptes Rendus, 132. pp. 627–628, March 11, 1901.)—This is a special coherer. In an ordinary coherer of carbon or filings the particles should be as free as possible; in this instrument the author places the filings in an insulating paste, the pressure on which can be adjusted by pistons pressing on it at each end of the tube in which the paste rests. The paste is made preferably of glycerine mixed with sulphur, lycopodium or silica, and the filings are of silver. When a discharge passes in the instrument its resistance is reduced, as is usual, but the author considers that there is a great advantage in replacing air by this liquid dielectric between the particles. The *rôle* of the powder is to hinder permanent coherence and to distribute pressure.

No relay was used when the instrument was used to take up signals across a large hall. The signals are heard by a telephone which is in series with the coherer and the cells. Ph. E. S.

1313. *Coherer Action.* **P. E. Shaw.** (Phil. Mag. 1. pp. 265–296, March, 1901.)—This paper is a very valuable contribution to our knowledge of the nature of coherence between metallic particles due to the incidence of electromagnetic waves. The coherer is here reduced to its elements—two wires at right angles to each other and touching at one point—and the force of coherence is measured. One of the wires projects horizontally from the suspended moving coil of a galvanometer, while the other is fixed vertically to the galvanometer stand. The force of coherence is measured by the current in the galvanometer coil necessary to separate the wires. In some experiments on the distance of separation over which coherence could take place the Electric Micrometer was used. The coherer was joined up in circuit with a battery, ammeter, and voltmeter, so that the resistance at the point of contact could be easily measured.

The following are some of the conclusions arrived at :—

1. The insulating layer between the surfaces of the contact is of importance before the first coherence has occurred. A layer of condensed air or gas might produce the well-known resistance. Oxide as such asserts itself when strong currents pass with certain easily oxidised metals, but this is a special case and does not affect the above statement.

2. In certain cases there actually is a bridge of metal formed between the surfaces and rigidly connected to both.

3. A peculiar molecular change (called orientation) has been brought to light. After coherence has taken place and the current has passed through the coherer in one direction, suppose decoherence to be brought about so that no current now passes; if then the direction of the e.m.f. in the coherer circuit be reversed, coherence immediately occurs. J. B. H.

1314. *Testing Coherers.* **C. Kinsley.** (Phys. Rev. 12. pp. 177–183, March, 1901.)—Experiments are described which show that the sensibility of a coherer is indicated by the steady potential which must be applied to it in order to cause it to "cohere." The same coherers were tested in the laboratory and on a telegraph station of the U.S.A. Signal Corps. The

average of twenty-four experiments, in each case, gives 2·2 volts as the breaking down potential for one of the coherers, 3·8 volts for a second, and 5·5 volts for a third. The first, when tested telegraphically, proved to be more sensitive than the second, and the second than the third. The final value of the resistance when broken down is very different for coherers of the same sensibility. This necessitates alterations in the adjustment of the relay to suit each coherer in order to obtain the best results. Coherers of any desired degree of sensitiveness may be made from any metal by taking the proper precautions, the most important being that the filings should be perfectly free from oxidation. J. E.-M.

1315. *Oscillator for Stationary Electric Waves.* **Bernouilli.** (Electrician, 46. pp. 737–738, March 8, 1901.)—The apparatus is intended for the production of stationary waves in a pair of long parallel wires, as in Hertz's experiments. The primary consists of two semicircular conductors, terminated in small brass spheres, which are connected to the secondary of a high-frequency coil. Directly below the primary, and in a parallel plane, is the secondary of the oscillator, which is a wire bent into a circle of the same radius as that formed by the primary. Primary and secondary are enclosed in a vessel containing oil. The ends of the secondary are connected to the long parallel wires. When the primary spark-gap is properly adjusted the wires are luminous along their entire length. If conducting bridges be now placed at the proper places to give stationary waves all the nodes become dark, the rest of the wire remaining luminous. J. E.-M.

1316. *Propagation of Electric Waves through Water.* **C. Gutton.** (Comptes Rendus, 132. pp. 543–545, March 4, 1901.)—When the electric and magnetic properties of an insulator only depend upon its dielectric constant, the wave-length of a resonator remains the same when measured first in air and then in the insulating medium in question. This proposition was deduced by Blondlot from considerations of homogeneity, and verified in the cases of castor-oil and ice. If the medium is magnetic or conducting, or if it shows considerable absorption for electric waves, its properties are no longer completely defined by its dielectric constant, and the equality of wave-lengths of a resonator in air and in the medium cannot be certain. This is the case with ordinary spring water, which shows a decided conductivity and consequent absorption of electric waves. The author therefore measured the wave-lengths of a simple resonator in air and in water, and found that they were practically the same when resonator and wires were either out in the air or immersed in water. He also found that the path traversed by the waves during one period of the resonator oscillating in air is 8·3 times smaller in water than in air. This implies that when a resonator is plunged into water its period of oscillation becomes 8·3 times greater than in air. E. E. F.

1317. *Reflection of Electric Waves by Metallic Surfaces.* **K. F. Lindman.** (Ann. d. Physik, 4. 3. pp. 617–637, March, 1901.)—Righi's results tending to show that waves reflected from a metallic surface may be ellipitically polarised are not confirmed by the author's experiments. He concludes that waves are not altered in type by such reflection. J. E.-M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1318. *Gaseous Dielectrics.* **E. Bouty.** (International Physical Congress at Paris, Report, 2. pp. 341–364, 1900.)—This paper is divided into two parts: the first deals with the measurement of the dielectric constant K for gases and vapours by various physicists, notably Boltzmann, Klemenčič, Lebedef, and Ayrton and Perry. A brief and more or less critical account of the various methods used is followed by various tables in which the values of K that have been obtained are compared with the results of theory, in so far as concerns the refractive index and its variation with different conditions. The results are compared with those that are obtained from the Mossotti-Clausius and Lorenz formulæ, and the deduction drawn that if for a liquid K is not equal to the refractive index squared, neither is it equal to that quantity when the substance is in the state of vapour. The suggestion is made that the variation of K with temperature, measured experimentally, would be useful in explaining the various discrepancies between theory and experiment. The second part of the paper deals chiefly with what Maxwell calls the electric strength of a dielectric, and results of experiments still in progress by the author are introduced. R. S. W.

1319. *Deformation of a Dielectric in an Electrostatic Field.* **P. Sacerdote.** (Journ. de Physique, 10. pp. 196–200, March, 1901.)—The increase of length of a solid dielectric in an electrostatic field the author has shown to be given by [see Abstract No. 1907 (1899)]—

$$\frac{\Delta L}{L} = (a + k)\frac{KH^2}{8\pi} = (a + k)\frac{KV^2}{8\pi e^2},$$

in which e is the thickness of the dielectric, a the reciprocal of the elasticity modulus, and k a coefficient called the coefficient of variation of the dielectric constant by a tractive force perpendicular to the lines of force.

If the condenser has the form of a dielectric tube with two metallic tubes concentric with it, one inside and the other outside as armatures and separated from it by a dielectric liquid, then it is shown that the term in the above formula containing a disappears, and the formula becomes—

$$\frac{\Delta L}{L} = k\left(\frac{KH^2}{8\pi}\right)$$

Elongation experiments with such an arrangement might give us at least some information regarding the sign of k, if not its actual magnitude. [See also following Abstract.] J. B. H.

1320. *Elongation of a Dielectric in an Electrostatic Field.* **P. Sacerdote.** (Phil. Mag. 1. pp. 357–359, March, 1901.)—The experimental results obtained by L. T. More in his paper on this subject [see Abstract No. 2440 (1900)] are here criticised. More concluded that no electrical deformations of dielectrics exist, but the author shows that by the very disposition of More's experiments the tube should not experience any appreciable elongation; thus the negative result merely proves that the experiments were carefully performed.

The author refers to two papers on this subject of which More seems to to have been ignorant: one by himself [Abstract No. 1907 (1899)] and one by Cantone (Rendiconti della R. Acc. dei Lincei, ser. 4, t. IV., pp. 344–353, 471–

477, 1888), and then calculates the elongation which his formula gives when applied to More's arrangement. This elongation is found to be within the limits of experimental error. [See also preceding Abstract.] J. B. H.

1321. *Measurement of Insulation Resistance.* **Meller.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 12–19, March 21, 1901.)—The usual formula for the measurement of insulation resistance by the *leakage method* is—

$$R = \frac{t}{C \log\left(\frac{V_0}{V}\right)},$$

where R is the resistance, C the capacity, V_0 the initial potential difference, and V the potential difference after the lapse of t seconds.

The author finds that this formula gives incorrect results since R is a function of V, or, what amounts to the same thing, a function of t. It is found that R is a linear function of t, so that

$$R = at + b,$$

where a and b are constants. W. G. R.

1322. *Electric Conductivity of Quartz and of Glass.* **F. M. Exner.** (Deutsch. Phys. Gesell., Verh. 3 4. pp. 26–30, 1901.)—The conductivity of a plate of amorphous quartz manufactured by Schott, of Jena, is here measured at temperatures between 100° and 150° C. The plate was clamped between two insulated steel vessels containing amalgam to serve as anode and kathode, and the condenser method of measuring high resistances was used. The specific resistance at temperature ϕ as compared with that of mercury at 0° is as follows :—

θ	S
101·0°	$4{\cdot}1 \times 10^{15}$
124·5	$2{\cdot}2 \times 10^{15}$
147·0	$0{\cdot}9 \times 10^{15}$

In these experiments the potential difference was 240 volts, and the thickness of the plate 9 mm., giving a potential gradient of 27 volts per mm. Sodium amalgam was used both as anode and kathode.—When an anode of mercury was used the numbers obtained for S were from five to six times greater than the above. A plate of rock crystal cut perpendicular to the principal axis had a specific resistance varying from $2{\cdot}3 \times 10^{12}$ to 5×10^{13} between the temperatures 109° and 148° C.

The conductivity of several glasses in the form of flasks suitable for Leyden jars was also measured at atmospheric temperature. J. B. H.

1323. *Experiments with Braun Tubes.* **H. T. Simon** and **M. Reich.** (Phys. Zeitschr. 2. pp. 284–291, Feb. 9, 1901.)—The authors describe with illustrations a stand for Braun tubes ; it consists of an upright with cross arms the tube passing through the centre of the cross, with its axis perpendicular to the plane of the cross. The arms of the cross are provided with grooves in which slide the coils used to deflect the rays. The authors point out the advantages of this apparatus in the lecture-room, when the rays are received on a fluorescent screen, and describe its use with a rotating mirror in showing alternate current curves, interrupter curves, hysteresis curves oscillatory discharges, phase-differences, Lissajous figures, &c. G. H. B.

1324. *Acoustic and Electrical Constants of the Telephone.* **M. Wien.** (Ann. d. Physik, 4. 3. pp. 450–458, March, 1901.)—The condition of the correct translation of speech by a telephone receiver is that the relative amplitude of different tones remains unvaried. To determine how far this condition is fulfilled, the following three points must be examined :—(1) The variation of current with frequency, at constant e.m.f. (2) The variation of magnetic induction with frequency, at constant current. (3) The variation of the amplitude of the diaphragm at constant magnetic induction.

The author has made experiments on four telephones—a Bell receiver, two Siemens receivers, and an Apel receiver—all four transmitting speech with equal distinctness. Their effective resistances and self-inductions were measured for frequencies up to 16,000, the source of current being a siren alternator, giving a sine wave. The effective resistance increases very rapidly, being in one Siemens telephone, 13 times greater at a frequency of 16,000 than the true resistance. The self-induction, on the other hand, diminishes ; in the case of the other Siemens telephone from $1{\cdot}17 \times 10^8$ at frequency 256 to $2{\cdot}3 \times 10^7$ at frequency 16,000. Assuming with Helmholtz that the e.m.f. in the telephone circuit is proportional to the frequency, the current varies as $p/\sqrt{R^2 + p^2 L^2}$, where p is $2\pi \times$ frequency, or, as R is small compared with L, as 1/L. For the Siemens telephone, the current would be 3·4 times as large at frequency 16,000 as at frequency 256, and the corresponding tone-intensity $(3{\cdot}4)^2 = 11{\cdot}5$ times greater. On the other hand, the magnetic induction, and with it the amplitude of the diaphragm and the tone-intensity, diminishes with the frequency. In the same telephone the tone-intensity would, for this reason, be 25 times smaller at frequency 16,000 than at frequency 256. The variations in tone-intensity due to these two causes tend to counteract each other, and the resulting variation with frequency must be determined for each single telephone.

The resonance tones of the diaphragm also have a considerable influence on the intensity of certain tones. The author has measured the frequencies which give resonance, and finds the more marked to be, in the Bell telephone, 1,100, 2,800 and 6,500, while in the Siemens, 720, 2,100 and 5,000. He has also measured the minimum current producing an audible tone, at different frequencies. For the Bell telephone this is, in units of 10^{-8} amperes, 19,000 at frequency 64, a minimum of 18 at 1,024, a second minimum of 70 at 2,800, and 12,000 at 16,000 ; while for the Siemens telephone there are minima of 0·8 and 1·0 at frequencies 720 and 2,400, rising to 1,200 and 1,700 at 64 and 16,000. All the telephones show maximum sensitiveness between frequencies of 500 and 3,000—frequencies which include the more important tones of the voice ; the very rapid loss of sensitiveness at lower and higher frequencies is probably due more to the ear than to the telephone. The author concludes that the telephone is very far from correctly reproducing a composite tone. G. H. B.

1325. *Modified Callendar-Griffiths Key.* **G. Kucera.** (Phys. Zeitschr. 2. pp. 381–382, March 30, 1901.)—If the magnetic system of a galvanometer is a light one and the instrument is in a very sensitive condition, the thermo-currents are very troublesome when it is a case of measuring rapidly changing resistances. If the circuit is such that great temperature differences at the various parts of it are unavoidable, as in platinum thermometry, then the Callendar-Griffiths key does not entirely get rid of them. The author shows how, by a simple addition, the key may be made more effective. In principle it consists in short-circuiting the branch in which the thermo-currents appear, so that the current produced tends to equalise the temperature differences at the junctions. R. S. W.

1326. *Dial Resistance Bridges.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 22. p. 257, March 21, 1901.)—The dial contacts are arranged in a circle, with the inside edges bevelled; a central circular piece, to which contact is made, has its outer edge bevelled in the opposite direction, this and the contact pieces forming an annular V groove. Contact is made between the two sides of the groove by two spring brushes, one bearing on each side of the groove; each brush consists of three springs, bearing on different portions of the bevelled edges. The brushes are fixed to a vertical shaft terminating in a handle which protrudes above a cover protecting the contacts and brushes. The resistance of the contact does not vary by 0·001 ohm. G. H. B.

1327. *Electrostatic Voltmeter for very High Pressures.* **G. Benischke.** (Elektrotechn. Zeitschr. 22. p. 265; also Discussion, p. 265, March 21, 1901. Paper read before the Elektrotechnische Verein, Jan. 22, 1901.)—The instrument is of the ordinary type of electrostatic voltmeter, made by the Allgemeine Elektrizitäts-Gesellschaft, for pressures up to 7,500 volts. It is also provided with a scale reading to 25,000 volts; for use at this pressure the circuit is connected to the terminals of three condensers in series, while the voltmeter is connected to one of the condensers. The scales, however, are not exactly in the ratio of 3 : 1 as the condensers are not usually exactly similar; each scale is therefore specially calibrated. The dielectric employed is micanite, and the condenser is fixed to the base of the instrument.

Discussion.—**Görges** gave particulars of the condenser employed by Siemens and Halske for the same purpose; micanite, however, was found unsuitable, as the capacity varied with age. The same firm now employs porcelain plates as dielectric; the condenser may be of exceedingly small capacity, two plates of 25 sq. cm. with dielectric 5 mm. thick being sufficient. G. H. B.

1328. *Electrolytic Contact-breaker.* **J. Härdén.** (Elektrotechn. Zeitschr. 22. pp. 257–258, March 21, 1901.)—The author first describes the difficulties met with in the continued use of the various contact-breakers now on the market, in connection with a coil giving 50 mm. sparks, and supplied by direct current at 135 volts. In the turbine mercury contact-breakers, the mercury very soon becomes too oxidised for use, and the edges of the contact teeth become eaten away; with a motor contact-breaker under petroleum the same difficulty was found. In the electrolytic contact-breaker of Wehnelt type, the platinum contact was worn away so rapidly as to form an expensive item in working. In Simon's type, either the glass wall cracked or the hole became enlarged till interruptions ceased.

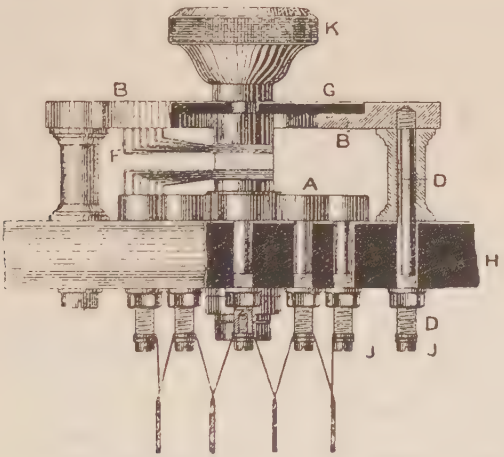
The form designed by the author consists of an ordinary porcelain petticoat insulator, placed head downwards in an outer vessel of lead, forming the kathode and filled with acid; a 1·5 mm. hole was bored vertically through the head of the insulator, and a lead strip forming the anode was held in the insulator. A water-jacket surrounds the lead vessel, and the temperature is maintained at about 40° C. The contact-breaker works well, giving about 75 interruptions per second, and so far the hole has shown no signs of becoming enlarged. At first a glass tube was employed in the place of the insulator, which caused the phenomenon that when current was switched on the liquid in the tube was driven out; the interruptions then ceased, but were re-established by the liquid again entering the tube and rising above the outside level; it then began sinking, and the process was repeated continuously. With the insulator, however, the opposite effect was produced,

namely, the liquid rose in the insulator when current was switched on, and then continued sinking and rising to a small degree, without ceasing to work ; the insertion of an inductive resistance in the circuit diminished this effect.

G. H. B.

1329. *An Improved Lever-switch for Resistance-boxes.* **R. Franke.** (Elektrotechn. Zeitschr. 22. pp. 275–276, March 28, 1901.)—In this switch the spindle bearing the lever-arms does not serve as a conductor and is not subjected to any mechanical stresses when at rest, since the movable contact surfaces are arranged at the ends of a line perpendicular to the fixed contact surfaces which lie in two opposite parallel planes.

As shown in the Figure, a strong brass plate, B, in the form of a ring, is



mounted on three columns, through one of which, D, the current passes to the ring. The brushes, F, transmit the current from B to one or other of the contact-blocks, A, these brushes being mounted on a spindle which can be turned by means of an ebonite handle, K. The resistance between A and B is about 0·0005 ohm in the laboratory form of the switch. A modification is shown, adapted for workshop use, in which the plate B is in the form of a disc supported on a central pillar, about which turns a sleeve bearing the brushes.

C. K. F.

1330. *A Simple and very Sensitive Quadrant Electrometer.* **F. Dolezalek.** (Deutsch. Phys. Gesell., Verh. 3. 2. pp. 18–22, 1901.)—The needle or needles in this quadrant electrometer are made of silver paper for lightness and are suspended on a quartz fibre. . After the fibre has been attached to its end fastenings by sealing-wax, it is dipped into a solution of hygroscopic salt such as calcium or magnesium chloride. The fibre and wax thus get a thin coat of the salt which always contains sufficient moisture to make the surface conducting, so that the needle can be charged along the fibre. The instrument can be made extremely sensitive by choosing a fine fibre ; with the needle charged to 110 volts and a fibre 0·009 mm. diameter, the period of the needle was 18 seconds and the sensitiveness 0·1 scale divisions at 2 metres distance for 4×10^{-5} volts.

The instruments are made by Bartels, Göttingen.

J. B. H.

ALTERNATING CURRENTS AND MAGNETISM.

1331. *Magnetic Expansion of Iron and Nickel.* **P. E. Shaw** and **S. C. Laws.** (Electrician, 46. pp. 649–651, Feb. 22, and 738–740, March 8, 1901.)—By the aid of P. E. Shaw's Electric Micrometer [see Abstract No. 523 (1901)], the authors have been able to measure changes in length as small as 5×10^{-8} cm., and thus to investigate the curves, connecting magnetic field with change of length, very close to the origin. Bidwell, using an optical lever, measured to $1{\cdot}4 \times 10^{-6}$ cm., and Nagaoka to 2×10^{-7} cm. The Electric Micrometer has

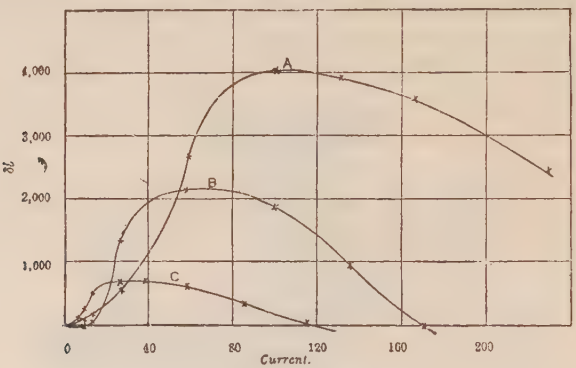


Fig. 1 —Iron Curves.

a graduated screw, whose movement is reduced, by the joint action of a set of six levers, say 1,000 times. The lever furthest from the screw carries a contact bead of iridio-platinum placed near a plate fixed to the body whose movement is to be measured. The contact bead and plate, when they touch, complete an electric circuit, which includes a telephone used by the experimenter, and thus the exact position for contact can be ascertained with great

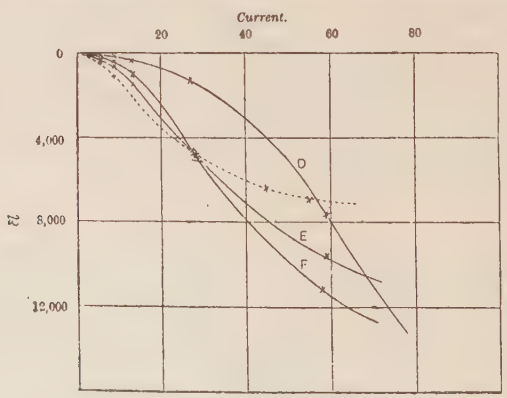


Fig. 2 —Nickel Curves.

delicacy. A description and diagrams are given of the arrangements used for the research. It was necessary to carefully protect the specimen from the heat of its exciting coil, as a rise in temperature of 1° C. would correspond to a reading of 10,000 scale divisions on the micrometer. Three iron rods were tested, of lengths 7·4, 7·7, and 7·9 cm., and of diameters 0·49, 0·26, and 0·10 cm.; the results are shown in curves A, B, C respectively in Fig. 1.

The values of δl, the change in length, are in terms of 10^{-8} cm., and currents are given in hundredths of an ampere. The magnetising coil had 1,064 turns and was 8·6 cm. long. The smallest reading of δl for the thick bar was —9, but the scale of the curves is too small to show the readings close to the origin. A list of the actual readings is given in the paper.

Nickel was found to be easier to examine than iron on account of its smaller residual magnetisation, its uniform purity in different specimens, and the simpler character of its curves. Three rods were tested, having lengths of 7·6, 8·0, and 7·9 cm., and diameters 0·75, 0·19, and 0·10 cm. These are denoted D, E, F respectively in Fig. 2. The dotted curve is obtained by extrapolation, as explained in the paper, and gives the probable readings for a rod of infinitesimal diameter and of the same length as those tested. The scales are as given above. W. H. E.

1332. *Calculation of Permanent Magnets.* **J. Busch.** (Elektrotechn. Zeitschr. 22. p. 234, March 14, 1901.)—Taking the magnetomotive force of a permanent magnet as being about equal to the product of the length of the magnet, and the coercive force corresponding to the flux in the steel, the length of magnet required to produce a certain flux (B) in a short air-gap (l) is Bl/coercive force. Additional length must be allowed in order to overcome the reluctance of the magnet itself and the pole-pieces. The author finds that the actual flux agrees with his estimate within 10 per cent. in practical cases. W. H. E.

1333. *Permanent Magnets.* **I. Klemenčič.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 827–836, 1900.)—The causes of decrease of magnetic moment with time are discussed in this paper. Hansteen tried to express the change of moment with time by a formula which was only in rough agreement with the results of experiment. Lamont, who showed that it depended on the temperature fluctuations throughout the year, considered it doubtful whether the loss of strength at the beginning and later was according to one and the same law. Klemenčič takes up this view, and assigns the loss chiefly to two causes: one, the after effects of magnetisation, which are responsible for the greatest loss, occurring in the first two days after magnetisation; and the other, the changes in molecular structure which are brought about by previous deformations, and especially by former temperature changes such as those by which the steel is hardened. Losses due to the second cause go on slowly, and are coincident with slow changes in other physical properties of the steel. Tables are given, from a previous paper [see Abstract No. 139 (1901)], which show that change of magnetic moment with time cannot be expressed by a simple formula such as Hansteen's. Klemenčič finds that the secular change has a factor depending on the time of year, although his magnets were, unlike Lamont's, kept in a heated room, and were not subject to great temperature oscillations, summer or winter. The greatest loss of moment takes place in the summer months, little or none in winter. G. E. A.

1334. *Residual Magnetism.* **C. Fromme.** (Ann. d. Physik, 4. 4. pp. 853–856, April, 1901.)—The author refers to Holitscher's experiments on residual magnetism [Abstract No. 646 (1901)], and claims that most of his results had been already shown by himself; the remaining conclusions arrived at by Holitscher the author criticises as incorrect in general, and attributes them to the fact that the experiments were confined to a single specimen of iron. Holitscher found that when, by repeated application of a certain

magnetising field, the residual magnetism had reached a limiting value, not only a stronger field but also a weaker field increased the residual magnetism, but that no field, of whatever strength, provided it were in the same direction, could diminish it. The author, on the contrary, found that the application of a slightly weaker field increases the residual magnetism, but that a considerably weaker field diminishes it, and that there exists a certain field of intermediate strength which does not change it. Holitscher further found that the residual magnetism increased with the time of magnetisation, without reaching a limit in the experiments; this is contrary to Frankenheim's experience, and the author attributes Holitscher's continued increase rather to the repeated application of the magnetising field than to the time of magnetisation. G. H. B.

1335. *Magnetic Precession.* **A. Schuster.** (Phil. Mag. 1. pp. 314–324, March, 1901. Paper read before the Physical Society of London, Dec. 14, 1900.)—Hertz showed that the most delicate method of investigating the influence of inertia is based on the apparent e.m.f.'s which are induced by the motion of conductors. If electricity possesses inertia, rotation of a body through which currents pass affects the flow of these currents in the same manner as the earth's rotation affects the direction of currents of air on its surface. Hertz obtained only negative results, but could fix an upper limit to the possible inertia of electric currents. It occurred to the author that this inertia, even if below the limits given by Hertz, might show accumulated effects when the currents last for a sufficient time. If the earth's magnetism be due to electric currents, the effects of inertia might explain secular variation. The present investigation shows that inertia would indeed cause a "magnetic precession" precisely of the character of the secular variation, but that this precession would be very much slower than the variations which are actually observed. [See also Abstract No. 1095 (1901).] E. E. F.

MEDICAL ELECTRICITY.

1336. *Energy Transformation in the Organism.* **A. Broca.** (International Physical Congress at Paris, Report, 3. pp. 495–522, 1900.)—In the first thermodynamical part, the author wishes to show that the muscular phenomena, though neither reversible nor probably electrical in nature, are analogous to those of the electric pile. Stress is laid upon the observation, made by the author and Richet, that the cooling which takes place during the first moments of muscular contraction is independent of the temperature of the body, but dependent upon the percentage of oxygen in the blood, and may, in want of oxygen, mask the heat generation; in such a case, the muscle appears rigid and unexcitable. The second part deals with the return of the excited organ to equilibrium. According to the author and Richet, the grey substance of the brain responds to electric excitation only by one wave which resembles Kelvin's e.m.f. wave in cable signalling, so that there must be something in the grey matter capable of reacting by a kind of impulse of the opposite direction. The refractory period, during which the grey substance does not respond to any fresh impulse, is 0·1 second. For the electrically excited nerves themselves, Charpentier has observed a wave period of $\frac{1}{800}$ second, the wave travelling 28 m. per second in a frog's nerve. The paper further refers to Charpentier's retinal undulations, based upon the study of the black bands observed when an opaque disc, out of which a sector has been cut, revolves in front of a source of light. H. B.

REFERENCES.

1337. *Coherers.* **G. Schlabach.** (Phys. Zeitschr. 2. pp. 374–376, March 23, and 383–387, March 30, 1901.)—A full notice of the bibliography of the subject.

1338. *Therapeutic Use of Ozone.* **H. Bordier.** (Archives d'Él. Médicale, 9. pp. 16–35, Jan.; and 85–103, Feb., 1901.)—Report to the French Association for the Advancement of Science.

1339. *Standard Cells.* **G. Gouy.** (International Physical Congress at Paris, Report, 2. pp. 422–439, 1900.)—A summary of the present state of our knowledge on this subject. W. R. C.

1340. *Field of Slowly Moving Electrons.* **C. H. Wind.** (Archives Néerlandaises, 5. pp. 609–635, 1900.)—This paper contains a mathematical treatment of the properties of the field produced by the movement of electrons and a deduction of the elementary electromagnetic and electrodynamic laws from the electron theory. The electron is regarded as a spherical shell uniformly charged throughout its volume, but for comparison there are given the different results arising from regarding the shell as very thin, or as a solid sphere. W. E. T.

1341. *Counter E.M.F. in the Electric Arc.* **V. v. Lang.** (International Physical Congress at Paris, Report 3. pp. 183–196, 1900.)—This paper gives a *résumé* of the experiments and theories on the fall of potential across the electric arc from 1860 to the present date. E. C. R.

1342. *Dispersion in Metals.* **P. Drude.** (International Physical Congress at Paris, Report, 3. pp. 34–46, 1900.)—An account is given of the author's theory [see Abstract No. 1833 (1900)] of dispersion in metals based on the consideration of electrons, and of its agreement with the results of experiment and the known properties of metals. In addition to points referred to in that Abstract, attention is drawn to the possibility of deducing the number and mobility of the conducting electrons from the other properties of the metals, of calculating the constants of the insulating electrons from their optical properties, and of inquiring further into the question of the variation of the electric conductivity of metals with temperature. W. E. T.

1343. *Equations of Electrodynamics for Moving Bodies.* **E. Cohn.** (Archives Néerlandaises, 5. pp. 516–523, 1900.)—A mathematical discussion of Maxwell's, Hertz's, and Lorentz's electromagnetic equations, and their measure of accord with experimental facts. E. H. B.

1344. *Electrodynamical Laws.* **E. Wiechert.** (Archives Néerlandaises, 5. pp. 549–573, 1900.)—A mathematical treatment of electromagnetic theory based on the work of Maxwell, Hertz, and Lorentz. E. H. B.

1345. *Coherers.* **E. Branly.** (International Physical Congress at Paris, Report, 2. pp. 325–340, 1900.)—A summary of this subject. Mention is made of the materials and conditions of their use for the making of sensitive coherers. Some experiments are given which prove that a certain large voltage, about 200, is the most effectual. The theories of Branly and Lodge are compared and are weighed in connection with present known facts. P. E. S.

1346. *Effect of Current Variations on a Steel Needle and an Iron Disc.* **M. Hornemann.** (Ann. d. Physik, 4. 3. pp. 481–512, March, 1901.)—A compendium of comparative experiments on the behaviour of a steel needle and of a soft iron disc, when suspended in turn at the centre of a coil through which a current is passed or reversed, or through which the discharges from a Leyden jar or an influence machine are passed. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1347. *Approximation of Atomic Weights to Whole Numbers.* **R. J. Strutt.** (Phil. Mag. 1. pp. 311-314, March, 1901.)—The fact that a very large number of atomic weights approximate to whole numbers is here treated as a problem in probabilities, and the chance of their being so near to whole numbers is calculated, supposing the atomic weights had been fixed by chance alone.

The differences between the atomic weights and the nearest whole numbers are taken and summed, and the chance that this sum is as small as the observations make it is calculated. Thus, taking the eight elements whose atomic weights are known to the third decimal, the chance works out at 1 in 1,000; taking 27 elements whose atomic weights are known to the second decimal, the chance is 1·7 in 1,000.

It appears, then, that the atomic weights tend to approximate to whole numbers far more closely than can reasonably be accounted for by any accidental coincidence. J. B. H.

1348. *Molecular Weights and Constitutional Formulæ.* **Lespieau.** (Soc. Franc. Phys., Bull. 165. pp. 3–4, 1901.)—Apart from the atomic theory and Avogadro's hypothesis, the study of the chemical reactions of a compound enables a constitutional formula, and hence a molecular weight, to be assigned to it. The agreement between the results thus obtained by purely chemical means and those based on physical data is a strong argument in favour of the atomic theory. N. L.

1349. *Compressibility of Solutions.* **Guinchant.** (Comptes Rendus, 132. pp. 469–472, Feb. 25, 1901.)—Experiments were made on the less complex solutions, such as those of organic compounds in water, in the hope of finding simpler and more general laws than the very varied ones hitherto given. It was sought to find an expression for the variation of the volume of the dissolved body with pressure. By the volume of the dissolved body is meant the difference between the volume of the solution and the volume of the solvent, and the author finds that the volume of the dissolved body is independent of the pressure, at least up to the pressure of 4 atmospheres. It seems, then, that the variation of volume which accompanies the simple solution of a body in water is due to a variation in the state of aggregation of the solvent rather than to the volume occupied by the dissolved molecules. The method of observation employed by the author was a method of comparison analogous to that of Schneider [Röntgen and Schneider, Wied. Ann. 29. p. 165].

J. J. S.

1350. *Study of Growing Crystals by Instantaneous Photomicrography.* **T. W. Richards** and **E. H. Archibald.** (Amer. Acad., Proc. 36. pp. 341–353, March, 1901.)—Frequent photomicrographs of crystals of various substances were taken during their birth and growth, an enlargement of four thousand diameters being obtained. The salts examined—potassium iodide, barium chloride, copper sulphate, &c.—were crystallised from aqueous solution, and both polarised and ordinary light were employed. No properly focussed image on any of the plates seemed to be devoid of crystalline

structure. The growth of the crystals is much more rapid in the first than in the later stages, the cube of the diameter being very approximately proportional to the time. The conclusion is arrived at that whatever theoretical reasons there may be for believing that crystals always develop from a transitory liquid phase, the present experimental evidence is inadequate to prove that the globules of such a phase attain a size visible in the microscope, except in the case of substances having melting-points not far from the temperature of crystallisation. The paper, which is illustrated by three plates and a diagram, is regarded as suggestive of a mode of study rather than as a finished treatment of the subject. N. L.

1351. *Method of Obtaining Crystals in a Solution without Formation of a Superficial Crust.* **A. Wróblewski.** (Acad. Sci. Cracovie, Bull. 8. pp. 319–325, 1900. Also Zeitschr. Phys. Chem. Jan. 22, 1901.)—The formation of a superficial crust is often a serious obstacle to the production of pure, well-formed crystals of organic substances by the ordinary methods. In the apparatus here described and figured the solution is placed in a tube, closed at the bottom by a parchment membrane, which fits closely into a bottle containing calcium chloride. Evaporation takes place through the membrane from the lower layers of the solution, the aqueous vapour being absorbed by the calcium chloride. N. L.

1352. *So-called Liquid Crystals.* **G. Tammann.** (Ann. d. Physik, 4. 3. pp. 524–530, March, 1901.)—Crystals of certain substances, notably *p*-azoxyanisol and *p*-axoxyphenetol, although perfectly clear in the solid state, when melted give rise to turbid liquids which appear bright when viewed between crossed Nicols. Lehmann has explained this behaviour by supposing that such compounds retain their crystalline structure in the liquid state. The author regards this view as by no means proven, and considers the turbid liquids obtained from the two above-named substances as emulsions of a brown reduction product which is formed in large quantity in the preparation of the esters from *p*-nitrophenol, the change from the turbid to clear liquid at a higher temperature being due to the greater solubility of the reduction product. It is pointed out that mixtures of powdered glass and water, emulsions of phenol and water, as well as other turbid non-crystalline media, give a bright field between crossed Nicols, and this to a greater extent as the particles in the turbid medium are made finer and more numerous. The fact that, when rotated between crossed Nicols, such liquids show definite directions of extinction is no proof of their crystalline character, and the great stability of the distribution of the dark and light portions of the field, which are altered neither by rapid and great changes of temperature nor by briskly moving the liquid by pushing the cover-glass to and fro, shows that the change in brightness of the field on rotation of the liquid is not due to double refraction peculiar to the so-called liquid crystals, but to the adhesion of the fine particles of the emulsion to the cover-glass.

An objection which may be urged against the author's theory is that when such liquids are heated a sudden change in their volume occurs at the point where the turbidity disappears. This fact was noted by Schenck, whose data show that the coefficient of expansion of the turbid liquid increases rapidly with rise of temperature, so that it is possible that the isotherms of the turbid liquid are continuous curves having a sharp change in direction at the temperature at which the liquid becomes clear.

Experiments made by the author with *p*-azoxyanisol and cholesteryl benzoate seem to indicate that they are not homogeneous chemical compounds, but no certain result is arrived at. T. H. P.

1353. *Pressure-volume Diagram.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 179–181, March, 1901.)—The author calls attention to the usefulness of the limiting lines in the volume-pressure plane corresponding to the network referred to by Duhem [see Abstract No. 1151 (1901)] for the pressure-temperature plane in the case of the binary system formed by two liquefiable gases. If a two-phase system of mean concentration S be in equilibrium at temperature T and pressure π, we can determine the concentrations S_1 and S_2 of the phases from the network in the T, π plane. A line now drawn in the v, π plane parallel to the volume axis through the known point v, π (v being the mean specific volume) intersects the dew line of the mixture S_1 at a point v_1, π and the boiling line of the mixture S_2 at a point v_2, π, where v_1 v_2 are the specific volumes of the vapour and liquid phases. Moreover, the point v, π divides the line (v_2, π), (v_1, π) in the ratio of the masses of the phases.
W. E. T.

1354. *Fundamental Equation of a Multiple Point.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 170–178, March, 1901.)—The author deduces mathematically a relation between the slopes of the intersecting curves at any multiple point, corresponding to the relation known to exist between the slopes of the three curves, which represent in the pressure-temperature plane the equilibrium of three one-component univariant systems. It is shown that the equation may be written in the form—

$$\Sigma_1^{n+2} Q_i \frac{dT_i}{d\pi_i} = 0$$

where Q denotes the heat absorbed by the ith univariant system during the corresponding change at the multiple point, and T is the temperature of the multiple point. W. E. T.

1355. *Dissociation Studies. II.* **W. D. Bancroft.** (Journ. Phys. Chem. 5. pp. 182–192, March, 1901.)—The phenomena exhibited by the various forms of ethyl aldehyde are discussed in the light of Duhem's theory. When no catalytic agents are present, acetic aldehyde and paraldehyde behave as one component system and mixtures of them as two component systems.

When a catalytic agent ($COCl_2$, HCl, SO_3, $ZnCl_2$, $CH_3.COCl$, $Cu_3.COBr$, H_2SO_4, $(CN)_2$, C_2H_5I) is present, a reversible equilibrium is attained if the speed of working does not exceed the velocity of reaction. This consideration offers a satisfactory explanation of the experimental facts so far as acetic aldehyde and paraldehyde are concerned.

When metaldehyde comes into the question the state of affairs is not so clear. It seems that metaldehyde must be regarded as an isomeric form of paraldehyde which, in presence of a sufficiently powerful catalyser, passes into the latter form. It stands, therefore, as an intermediate form between acetic aldehyde and paraldehyde. Theoretically there must be a temperature above which metaldehyde will liquefy to a mixture of acetic aldehyde and metaldehyde, and below which acetic aldehyde will solidify completely to metaldehyde, provided always that the change of metaldehyde into paraldehyde be prevented. [See further Abstract No. 1222 (1899).]
F. G. D.

1356. *Electromotive Behaviour of Substances with Several Degrees of Oxidation, II.* **R. Luther.** (Zeitschr. Phys. Chem. 36. pp. 385–404, March 12, 1901.)—The e.m.f. of the reaction $Cr''' \longrightarrow CrO_4''$ is about $-1{\cdot}8$ volts, and of Cr (metal) $\longrightarrow CrO_4''$, probably about 0·9 volts.

The equilibrium between cupric and cuprous sulphate in presence of metallic copper was determined by titrating the cuprous salt with potassium permanganate. The equilibrium-constant, $Cu''/(Cu^1)^2$, was found to be $1{\cdot}5 \times 10^6$ at 25° C.

The e.m.f. of the system

Hg | $HgCl_2$ (1 mol. in 50 l.) | KCl (1 mol. in 40 l.) is $-0{\cdot}750$ volts;

from this it is calculated, by means of Nernst's formula, that the dissociation constant of mercuric chloride in aqueous solution is about $0{\cdot}5 \times 10^{-14}$. [See further Abstract No. 2467 (1900).] T. M. L.

1357. *Electro-chemical Relations of the Allotropic Forms of Silver.* **Berthelot.** (Comptes Rendus, 132. pp. 732–734, March 25, 1901.)—Four different forms of silver were examined, namely, (1) silver modified by the action of oxygen at about 550°, (2) silver precipitated by copper, (3) the same as (2) with subsequent heating, and (4) crystallised silver. Each of these in turn was made the electrode in a bath of 10 per cent. silver nitrate solution, and was connected by means of a wire and a galvanometer to the other electrode consisting of amorphous silver. In each case an immediate current was noticed, the amorphous silver being positive towards the other forms. The current thus developed diminishes rapidly at first and in less than a minute reaches an almost fixed value, which then gradually falls to zero. The currents could not be measured. T. H. P.

1358. *Dielectric Constants of Nitriles.* **H. Schlundt.** (Journ. Phys. Chem. 5. pp. 157–169, March, 1901.)—The dielectric constants of a number of nitriles were determined by Drude's method (Zeit. Phys. Chem. 13. 531, 1893), the cells used being calibrated with benzene, acetone, water, mixtures of benzene and acetone and of acetone and water. The results obtained are shown in the following table:—

Solvent.	Formula.	Temp.	Dielectric Constant (Air = 1).
Hydrocyanic Acid ...	HCN	21	95
Acetonitrile	$CH_3.CN$	21	36·4
Propionitrile	$C_2H_5.CN$	22	26·5
Butyronitrile	$C_3H_7.CN$	21	20·3
Isopropyl cyanide ...	$CHMe_2.CN$	24	20·4
Valeronitrile	$C_4H_9.CN$	21	17·4
Isobutyl cyanide ...	$CHMe_2.CH_2.CN$	22	17·95
Capronitrile	$CHMe_2.CH_2.CH_2.CN$	22	15·5
Benzonitrile	$C_6H_5.CN$	21	26·0
Benzyl cyanide ...	$C_6H_5.CH_2.CN$	21	14·9
o-Toluonitrile	$C_6H_4Me.CN$	23	18·4
Pyridine	C_5H_5N	21	12·4
Quinoline	C_9H_7N	21	8·8

In accordance with the Nernst-Thomson law that conductivity is determined by the dielectric constant of the solvent, it might be expected that the nitriles with high dielectric constants would be good conductors; the law holds good for the homologous series of aliphatic nitriles, as is shown by the

following table of molecular conductivities of silver nitrate in these solvents at 25° C. :—

Solvent.	v.	μ_v	Dielectric Constant
Acetonitrile	64·0	103·7	36·4
Propionitrile	63·7	46·0	26·5
Butyronitrile	75·6	25·4	20·3

But a solution of silver nitrate in propionitrile conducts about four times as well as a solution in benzonitrile, which has a slightly larger dielectric constant, and a solution in pyridine conducts better than a solution in butyronitrile, whose dielectric constant is nearly twice as large.

The most interesting result given in the paper is the exceedingly high dielectric constant of hydrocyanic acid ; this bears the same relationship to acetonitrile that water bears to methyl alcohol, or formic to acetic acid, and it is to be expected that it will give solutions of proportionately high conductivity. Measurements in this direction are in progress. T. M. L.

1359. *Spectrophotometric Study of the Hydrolysis of Dilute Ferric Chloride Solutions.* **B. E. Moore.** (Phys. Rev. 12. pp. 151–176, March, 1901.)—The author applies the spectrophotometric method to the examination of the hydrolysis of ferric chloride in aqueous solution, which was studied electrolytically by Goodwin in 1896. According to the latter author, part of the ferric chloride exists in the form of the ions Fe and 3Cl and the rest as the ions FeOH, H and 3Cl. At any time after diluting the solution, a certain number of the FeOH ions have disappeared, forming with water a colloid hydrate $(FeO_3H_3)_v$, so that at any instant there are present four components from which absorption of light may be expected, namely $FeCl_3$, Fe, FeOH, and $(FeO_3H_3)_x$. The author first discusses the theoretical aspect of the subject and the arrangement and method of using the apparatus employed, and afterwards gives tables of the numerical results and absorption curves plotted from them. The results show that a study of the absorption spectra is a good method for following the progressive changes in the formation of colloid hydrate and is useful whenever colour changes take place. Ionisation is detected and the non-transparency of the ions demonstrated, but no quantitative determination of the rate of ionisation is possible in the case studied. But slight evidence is exhibited for the existence of the two iron ions clearly indicated by the electrolytic method of examination, but the general agreement of the optical with the electrical method of finding the rate of formation of the final products leads to an acceptance of Goodwin's theory. It is possible that the molecules of the final product are not all of the same magnitude, that is, the value of x in the formula $(FeO_3H_3)_x$ is variable. The optical study of absorption spectra in regard to their relation to the molecular structure of solutions, is not so readily applied as the boiling-point, freezing-point, or conductivity method, but may be useful in showing complexity of structure not brought out by these other methods. T. H. P.

1360. *Softened Positive Accumulator Plates.* **F. Peters.** (Centralblatt für Accumulatoren, 1. pp. 125–128, 1900.)—After a certain number of discharges the active material of lead peroxide plates becomes soft and slimy, and finally drops from the grid. An exhaustive chemical analysis of the material from normal and from softened plates shows that in the latter case the material from the centre of the mass is considerably richer in available oxygen and in peroxide than that from the surface, whilst in the normal plates the difference

is but slight. In explanation of this it is suggested that the continued expansions and contractions caused by the charging and discharging of the accumulator bring about a loosening of the active material whereby the formation of peroxide in the interstices is favoured, whilst in the superficial layers the porosity and consequent imperfect contact with the grid is prejudicial to peroxide formation. The behaviour of the cell on discharging is shown to be in accordance with this explanation. The resistance of the active material is not appreciably altered by the softening. N. L.

1361. *Thermo-chemistry of Standard Cells with Dilute Solutions.* **W. Jaeger.** (Deutsch. Phys. Gesell., Verh. 3. 5. pp. 48–53, 1901.)—The e.m.f. of a Clark cell containing a zinc sulphate solution saturated at 6·75° was measured between + 40° and — 10° ; this solution contains 1 mol. $ZnSO_4$ to 19·77 mols. H_2O, and the e.m.f. of the cell is represented by the formula $E_t = 1{\cdot}44220 - 0{\cdot}0005300(t - 6{\cdot}75°)$. By applying Helmholtz's equation this gives the value 80170 cal. for the chemical energy of the cell.

The difference between the e.m.f. of this cell and that of a Clark's cell at temperatures above or below 6·75° gives a measure of the heat of solution of $ZnSO_4 . 7H_2O$ in a solution of the composition $ZnSO_4 + 19{\cdot}77\ H_2O$; this is calculated from the experimental data to be — 4527 cal. for the hydrate $ZnSO_4 . 7H_2O$, and hence, by adding the heat of hydration of this salt, the heat of solution of anhydrous $ZnSO_4$ in the solution $ZnSO_4 + 19{\cdot}77\ H_2O$ is calculated to be 22,690 — 4527 = 18160 cal. The heat of precipitation of mercury from mercurous sulphate by zinc to form anhydrous zinc sulphate is 55,070 cal., and applying the formula given by Cohen [Abstract No. 2064 (1900)] the chemical energy of the cell is calculated to be—

$$55{,}070 + \frac{19{\cdot}77}{19{\cdot}77 - 7}\,22{,}690 - \frac{7}{19{\cdot}77 - 7}\,18160 = 55{,}070 + 25170 = 80{,}240 \text{ cal.}$$

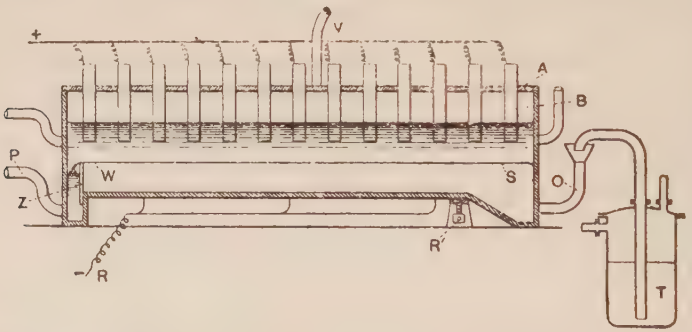
This value agrees very closely with that deduced from the e.m.f. and temperature coefficient of the cell. T. M. L.

1362. *Depression of the Freezing-point in Solutions Containing Hydrochloric and Sulphuric Acids.* **J. Barnes.** (Roy. Soc. Canada, Trans. 6. pp. 37–54, 1900.)—The freezing-points of aqueous solutions of hydrochloric and sulphuric acids were determined with the aid of a Beckmann thermometer and reading microscope. The convergence-temperature of the apparatus was found to be 0·04° C. above that of the protection-bath, and the latter was therefore adjusted to 0·04° below the freezing-point of the solution. The solutions were cooled to 0·3° below the freezing-point by means of a freezing-bath of ice and salt-water at — 10° C., and were then transferred to the protection-bath ; when the temperature had risen to within 0·1° of the freezing-point the freezing was started with a particle of ice and the temperature of the well-stirred solution noted. By this method a very high degree of accuracy was obtained ; thus six determinations of the freezing-point of a solution of hydrochloric acid containing 0·104 gram-molecules per litre were obtained within the limits 2·3080° and 2·3086°, the freezing-point of water being 2·6782° on the same scale.

The ionisation coefficients of the simple solutions at 0° were determined from conductivity measurements at 0° and 18°, and for the mixtures were calculated by means of the formulæ of the author and of McGregor. The depressions of the freezing-point in mixtures of hydrochloric acid and sulphuric acids were then calculated and compared with the observed values ; the differences were less than 0·002° in all but the two strongest solutions, and

lie within the limits of error of experiment and calculation. The depressions of the freezing-point of mixtures of solutions of hydrochloric and sulphuric acids up to an average concentration of 0·2 gram-molecules per litre can therefore be calculated according to the dissociation theory on the assumption that the sulphuric acid dissociates into H, H and SO_4, and that the molecular depression of an electrolyte in a mixture is equal to its value in a simple solution of the same total concentration. T. M. L.

1363. *Solvay Electrolytic Alkali Cell.* **J. B. C. Kershaw.** (Electrician, 46. p. 789, March 15, 1901.)—This is an account of a new form of electrolytic cell for the production of chlorine from alkaline chlorides. The kathode consists of mercury and the anodes of carbon rods, or platinum. The essential features of this cell (Engl. Pat. Nos. 7470 and 7471, 1898) will be seen from the illustration. Contrary to most mercury cells, there is no mechanical movement of the whole cell; the amalgam formed being lighter is made to



overflow into a well, partitioned off by means of an adjustable bridge (Z) and thence flows out through the pipe P into another cell, where it is decomposed by a reversal of current. The mercury is returned through the pressure vessel T into the cell through the funnel marked O, and the alkaline chloride solution is made to enter at B, thus passing over the mercury surface SW.

No figures as to efficiency are yet obtainable, but two installations of 1,500 h.p. each, in Belgium and Russia, producing 6,000 tons of alkali and bleach for each of these works, are in operation. O. J. S.

1364. *Soluble Alkaline Ferrates by Electrolysis.* **F. Haber.** (Écl. Électr. 26. pp. 453–456, March 23, 1901. Paper read before the Société Allemande d'Électrochimie.)—Potassium ferrate, K_2FeO_3, is obtained by fusing iron with potassium nitrate and also, as Poggendorf showed, by electrolysing a solution of caustic potash using an iron anode and an iron or platinum kathode. The author finds that cast iron is more effective than steel or wrought iron as the anode, and the yield is greater with soda than with potash; the electrolyte should be concentrated and heated to about 70°. Of the iron entering into solution, 62–74 per cent. is converted into ferrate, 2–14 per cent. is deposited on the kathode, and the remainder adheres to the anode. The dark red solution of the alkali ferrate obtained loses its colour on boiling, evolves oxygen, and then contains a *ferrite*. Much of the paper is of chemical interest only. N. L.

1365. *Motion of Ions in Chemical Reactions.* **O. Urbasch.** (Zeitschr. Elektrochem. 7. pp. 527–530, March 28, 1901.)—While experimenting on the

influence of magnetic fields on the formation of electrolytic deposits of paramagnetic and diamagnetic metals formed in the fields, the author's attention was drawn to the motion of the electrolyte which took place in the field. The rotation of the electrolyte was so sensitive, even for very small currents, that the idea occurred to the author of using this rotation as an indication of the currents or ionic wanderings which take place in a solution during chemical reactions.

The present paper contains a summary of a number of chemical experiments conducted in a strong magnetic field, such as the dissolving of metals by acids, the deposition of metals from solutions of their salts by the introduction of other metals, the diffusion of two electrolytes, &c., in all of which the motion of the liquid was studied. The motion was perfectly regular in every case and reversed itself when the magnetic field was reversed. A complete explanation of all the phenomena is not yet forthcoming, but in the case of the solution of metals by acids Drude's explanation seems to apply, namely, that the ions moving with equal velocities in the magnetic field would be deflected in one or other direction according to their charge, and the ion having greatest friction would take the insulator with it. J. B. H.

REFERENCES.

1366. *A Theorem of van der Waals.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 137–140, Feb., 1901.)—Employing Gibbs' thermodynamical formulæ, the author proves that in a two-component univariant system the temperature will in general pass through a maximum or minimum, and that when the concentrations of two of the phases become equal the curve representing the relation between temperature and one of the variable concentrations will have a tangent almost perpendicular to the temperature axis. These theorems are both due to van der Waals, and have been experimentally verified by Roozeboom. F. G. D.

1367. *Combustion of Gases.* **S. Tanatar.** (Zeitschr. Phys. Chem. 36. pp. 225–226, Feb. 8, 1901.)—Continuation of the work referred to in Abstract No. 410 (1901).

1368. *Lecture Experiments in Physical Chemistry.* **A. A. Noyes** and **A. A. Blanchard.** (Zeitschr. Phys. Chem. 36. pp. 1–27, Jan. 22, 1901.)—A number of experiments are described with great detail. The subjects dealt with and the number of experiments are as follows :—Ionisation, 7 ; Velocity of Reactions, 4 ; Chemical Equilibrium of Dissociated Systems, 6. F. G. D.

1369. *Determination of Decomposition Voltages.* **W. D. Bancroft.** (Journ. Phys. Chem. 5. pp. 133–136, Feb., 1901.)—Description of apparatus, with results. W. R. C

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1370. *Engines for the Glasgow Electric Tramways.* (Engineering, 71. p. 141, Feb. 1 ; and pp. 173 and 176, Feb. 8, 1901.)—There are four engines in all. Two are made by the E. P. Allis Company, of Milwaukee, and were described in Abstract No. 2333 (1900), and the other two by Musgrave, of Bolton. The Musgrave engines are to exert 5,000 h.p. at full load, and 4,000 at normal load. There is one h.p. cylinder of 42 inches diameter, and two l.p. cylinders of 60 inches diameter. The steam pressure is 150 lbs. per square inch, the revolutions 75 per minute, the electrical output being 2,500 kilowatts. The bed-plate is in five pieces, and besides the usual bolts special bosses are provided, over which massive steel rings will be shrunk when the bed-plate is in position in Glasgow, so as to ensure the rigidity of the whole structure. Clearances have been reduced to a minimum, and projections are cast on the pistons to fill the cylinder ports. The valves are of the Corliss cylindrical type. There are two distinct ball governors, one only coming into operation if the main governor fails to act. A reheater, heated by live steam from the boiler, is fitted between the h.p. and l.p. cylinders. Jackets are fitted to the h.p. cylinders but not to the l.p. cylinders. The flywheel is of the ordinary type, and weighs 145 tons. L. S. R.

1371. *Continental Steam Engine Practice at the Paris Exhibition.* **W. D. Wansbrough.** (Cassier, 19. pp. 36–50, 1900, and pp. 387–403, March 1901.)—As regards horizontal engines, no case of an entirely overhanging cylinder occurs, and the end of the trunk guide is always supported. Some of the makers cast the main plummer block separate, which indicates that the casting in one piece would be too large for them to handle ; this arrangement is not to be recommended, as should the bolts jointing the castings work slack, there is no possibility of tightening them up without lifting out the whole crank-shaft and flywheel. The flywheels are, generally speaking, too light for even and steady running. The various methods of construction are described and criticised. Several of the engines have a pad or semi-bearing to carry the weight of the piston and piston-rod and prevent the wear of the glands. The variety of design in the cross-heads of the various engines is a noticeable feature. The crank-pin ends of the connecting rods are generally of the solid end type, with adjustable wedge, or of the marine type. The valve gears are very numerous, but none are described in detail. Some ingenious devices for preventing the oil from splashing off the working parts are fitted and fully described. An account is given of several of the engines exhibited. L. S. R.

1372. *Corliss-Valve Engines and Gears.* **G. Windeler.** (Mech. Eng. 7. pp. 274–277, Feb. 23 ; 336–339, March 9 ; 378–379, March 16, and 424–426, March 23, 1901. Paper read before the British Institution of Draughtsmen) (Manchester Branch).—The tendency for larger units at slower speeds for large electrical work has led to the further development of the Corliss valve gear. The valves may be divided in three classes : (1) Valves at opposite corners. (2) Valves in covers. (3) Valves below cylinders.

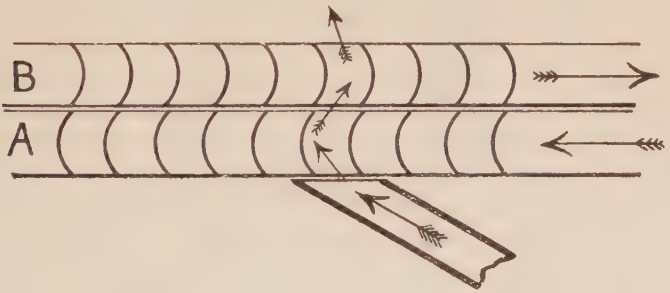
(1) The valves are so arranged in this class that any water finds its way immediately to the valves and so drains away. The valves are kept as near as possible to the cylinder, and clearances are reduced to a minimum.

(2) This class has the disadvantage that the drainage cannot be arranged for as in the previous type, but the clearances can be still further reduced.

(3) This arrangement is very compact, and lends itself particularly well to good drainage, but loss by initial condensation is greater.

A very large variety of arrangements of valves of different design, and placed in various positions in the cylinder and the covers are discussed and fully illustrated. The different forms of valves, governor gears, valve levers, wrist plates and rods, dash pots, &c., are fully described and their various merits discusssed, but the intricacies of their construction render it necessary to consult the original text for a proper comparison. L. S. R.

1373. *Seger Steam Turbine.* (Génie Civil, 38. pp. 313–315, March 9, 1901.) —Description of a turbine on the Laval principle, but having two discs



(A and B) which are rotated in opposite directions, the steam from the jet passing through both, as shown in the diagram. H. R. C

1374. *Tests on a 300-H.P. Laval Steam Turbine.* **W. Jacobson.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 150–151, Feb. 2, 1901.)—The use of steam turbines has developed of late, due to the small space they occupy, and so they can be installed in existing factories where the space is limited without destroying or increasing existing buildings.

A 100-h.p. Laval steam turbine was installed in January, 1898, in some German paper mills, and the experience gained with this turbine was so satisfactory that it was decided to fit one of 300-h.p. The dynamo was made by Ganz & Co., of Budapest, and the turbine by the Actiebolaget de Lavals Angturbin, of Stockholm.

The turbine runs at 10,500 revolutions per min., and the gear wheels reduce to 750 per min. There is an independent air pump driven by an electrical motor. Steam is generated in a Dürr boiler, and passes through a Kausch superheater on its way to the turbine.

When developing 300 h.p., with steam at 132·3 lbs. pressure, and a vacuum of 26·3 inches of mercury, the turbine consumed 18·3 lbs. per h.p. hour.

With steam at 446° F. ..... 17·2 lbs. per h.p. hour.
„ 572° F. ..... 17·0 „ „

The steam for driving the feed pump was taken from another boiler, and the water that was collected from the main steam pipe was carefully weighed.

The following are the results of the trials :—

Length of test	5·133 hours.
Mean steam pressure in boiler	154·5 lbs.
„ „ temperature in superheater	415·6° F.
Temperature of steam due to 154·5 lbs. pressure	364.8° F.
Mean steam pressure after valve of governor	127·1 lbs.
Mean vacuum : inches of mercury	27
Mean reduced speed	754·66
Brake h.p.	342·1
Water per b.h.p. per hour	15·7 lbs.

The falling off in economy is well shown in the following table :—

B.H.P.	Water per B.H.P. per hour. lbs.
337·6	15·67
293·9	15·76
249·2	15·91
[226·3]	[16·00]
162·8	16·25
118·9	16·70
73·5	17·99
30·4	21·77

The power to generate the current running the air pump motor was taken from an independent boiler, and it amounted to 7·5 h.p. The steam gauges were all tested against standard gauges, and the corresponding corrections made in the pressures. L. S. R.

1375. *Use of Liquid Fuel in Locomotives.* **J. Holden.** (Mech. Eng. 7. pp. 544–547, April 20, 1901. Paper read before the International Railway Congress at Paris, 1900.)—Extensive trials carried out on the Great Eastern Railway resulted in the equipment of 58 locomotives with apparatus for burning oil-fuel, and the construction of storage plant consisting of underground tanks holding 50,000 gallons of oil, which they receive by gravity from travelling tanks brought by rail. Six cylindrical tanks holding 42,000 gallons, 20 feet above rail level, receive oil by means of a rotary pump and steam engine, and distribute it to locomotives by means of filling posts or arms like water cranes. A main line express engine can take in 600 gallons in from four to five minutes. Air pressure from the brake pump of the locomotive is also used at country depôts to effect delivery of the liquid fuel. Improvements were also effected in the burners used to spray the liquid, in the number and disposition of burners used, the regulation of air and steam, and other points.

A single Great Eastern Express locomotive has run 138 miles in 175 minutes, with one stop of four minutes, on a consumption of 190 gallons of tar residues (sp. gr. 1·1) equivalent to 14·4 lbs., of oil fuel per train-mile, with 6 cwts. of coal used to light the fire and raise steam = 5 lbs. per mile, or a total of 19·4 lbs. per mile. The same system has been adopted in Austria, France, and the Far East. The saving in carriage is a great inducement to the adoption of liquid fuel, one ton of it being equal in effect to two of coal.

F. J. R.

GAS AND OIL ENGINES.

1376. 500 *H.P. Premier Gas Engine.* (Mech. Eng. 7. pp. 520–521, April 13, 1901.)—The engine has two motor cylinders arranged in tandem fashion, the pistons of which are connected by slide rods and crosshead. The front piston is of differential design and carries an enlarged end-piece in front, which works in a bored-out portion of the bed-plate, thus acting as a guide. Two side rods pass backwards from this end-piece on each side of the motor cylinder in passages cast in its casing, and by means of a crosshead connect with the projection of the back piston. Explosions take place alternately in the two cylinders. The space in which the large end-piece of the front piston works is used as an air-pump and a large volume of air is dealt with, enabling positive scavenging to be carried out to a satisfactory degree. Water-jacketing is applied to both valves and pistons.

Diagrams of indicator cards showing comparison of adiabatic and isothermal expansion, and others showing combined turning moments on the crank shaft and speed variations during one cycle, and also influence of inertia forces, are quoted from a paper on "Power gas and large gas engines," by H. A. Humphrey, in Trans. Inst. Mech. Engineers, Dec., 1900. F. J. R.

1377. *Late Practice in Utilising Blast-furnace Gas as a Gas Engine Fuel.* **W. H. Booth.** (Cassier, 19. pp. 341–348, March, 1901.)—The similarity in composition between producer gas and blast-furnace gas led to a trial of the latter in a 20-h.p. gas engine, applied to dynamo driving, at Wishaw Iron Works. In the author's test this installation gave 1 e.h.p. hour at the switchboard per 140 cubic feet of uncooled gas, equivalent to about 1½ lb. coal. In considering the action of a blast furnace as a gas producer, the author points out that the gas contains both dust and moisture; it has about 33 per cent. of combustible ingredients, and possesses an average heat value of 100 B.Th.U. per cubic foot. Purification is absolutely essential to its successful use in gas engines. The poverty of the gas in combustible elements is no drawback to its use in engines, because compression renders it easily inflammable even when at atmospheric pressure it would scarcely ignite. The proportions of the gas and air inlets of the engine must be suitably arranged.

Particulars of the Simplex engine of 700 h.p. and of the Oechelhaeuser gas engine at Hörde, are given, and reference is made to recent installations at the blast furnaces at Boulogne and at Sheepbridge, with the following analysis of the gases used at the two latter works :—

Blast furnace gas.	Boulogne. Percentage by volume.	Sheepbridge. Percentage by volume.
Carbonic acid (CO_2)	10·0	9·0
Carbonic oxide (CO)	28·0	22·0
Marsh gas (CH_4)	—	1·4
Hydrogen	62·0	6·8
Nitrogen		59·8
	100·0	99·0
Water Vapour	2·4	—
Thermal value in B.Th.U. at 60° F. per cubic foot.	118	105

The Boulogne engine is of the twin-cylinder type, of 300 i.h.p., working on the Otto cycle. When developing 175 e.h.p. the consumption of gas was 145·2 cubic feet per e.h.p. hour or 99·6 cubic feet per i.h.p. hour; the overall efficiency being 68½ per cent.

Although the most obvious use of large gas engines in connection with blast furnaces is that of blowing engines for the furnaces, yet such engines are being installed for the generation of electric power and for the manufacture of electrolytic products. One pound of calcium carbide can be produced for 2·464 e.h.p. hours, using 308 cubic feet of gas of a net value of 100 B.Th.U. or a total of 30,800 heat units. To produce this volume of gas, 4·058 lbs. of coke would be required, assuming one ton to yield 170,000 cubic feet of gas. The coke, representing 54,978 B.Th.U., would be produced from 6·243 lbs. coal of 14,700 B.Th.U. per lb. or 91,772 B.Th.U. in all. Part of the difference in heat value between the coal and coke would be recovered in tar, creosote, and ammonia. The calcium carbide would yield 5 cubic feet of acetylene gas of a total of 240 c.p. hours and of 7,845 B.Th.U. calorific capacity, or 25 per cent. of the calorific capacity of the gas used in the engine.

If the 2·464 e.h.p. hours were used to work arc lamps, the result would be 2,464 c.p. hours or tenfold the light of the acetylene; whilst incandescent electric lamps would yield 384 c.p. hours.

The author directs attention to the disposition of air and gas power cylinders in blowing engines, and decides in favour of the four cylinder horizontal engines with vertical blowing cylinder, as against the tandem arrangement of the Seraing engine.

Some remarks on improvements in furnace tops, and on the volume of gas produced per ton of fuel in the blast furnace conclude the article. F. J. R.

1378. *Water Gas as compared with other Combustible Gases.* **J. Körting.** Zeitschr. Vereines Deutsch. Ing. 44. pp. 1301–1308, and 1345–1348, 1900.)—The gases at present used for power and lighting purposes are: *Producer Gas*, obtained by the incomplete combustion of fuel under the action of an air blast. *Dowson Gas*, obtained in the same way, when the blast contains steam. *Water Gas*, obtained by the action of a steam blast on glowing fuel; the fuel is maintained at a high temperature by an air blast, which is alternated with the steam blast. *Coal Gas*, obtained by the dry distillation of bituminous coal. *Carburetted Water-gas*, obtained by the addition of petroleum to water-gas.

The compositions of these gases are as follows:—

	Producer Gas.	Dowson Gas.	Water Gas.	Coal Gas.	Carburetted Water-Gas.
CO	23–30	23–27	40	6–8	23–28
CO_2	2–7	6–7	3–7	1–1·5	0·2–2·2
H	2–6	17–18	50	46–48	34–38
N	50–65	47–52	3–6		2·5–5
O	traces				
CH_4, &c.		0·5–2		34–38	17–21
C_2H_4, &c.				3–5	13–16
Specific Gravity	1·0	0·83	0·51	0·4	0·58–0·6
Calories per cub. m.	850–1,000	1,200–1,400	2,350–2,600	4,800–5,200	6,000
Temp. of flame, degrees C.	below 2,000°	below 2,000°	2,700°–2,800°	2,300°–2,400°	

Water-gas is especially suitable for the incandescent gas light on account of its high flame temperature; in a Welsbach burner, two litres per hour give one Hefner-candle, while 1·8 litres of coal gas (of twice the calorific value) are required for the same light. Producer and Dowson gas cannot be used in

these burners. Water-gas, when in contact with iron, combines with it to form an iron carbonyl, which is deposited on the Welsbach mantle and quickly destroys it. When used for lighting, therefore, the iron gas-pipes must be protected by asphalting or galvanising.

The author then describes, with diagrams of the plant, the four principal methods of generating water-gas, namely, Fischer's, Humphrey and Glasgow's, Dellwik's [Abstract No. 897 (1900)], and the new method invented by Strache and installed by him in Pettau. Full details are given in each case of the consumption of coal and coke for heating and gas generating, and the efficiency of each process is worked out, and given as the ratio of the heat value of the fuel to that of the corresponding amount of gas. Similar details are also given for Dowson gas and for coal-gas, the figures referring to the latter being the average obtained from the statistics of two hundred installations for town supply. The figures are collected in the table below, the costs being reckoned on the assumption of the following prices of raw material and bye-products :—

100 kilos. steam coal	Marks	1·70
„ „ gas „	„	1·80
„ „ coke	„	2·00
„ „ tar	„	4·00
„ „ ammonia	„	18·00
„ „ benzoline	„	25·00
„ „ German gasoline	„	8·00
„ „ foreign „	„	14·00

The figures given in the table are the results of actual working, and not of experimental tests. All incidental losses are included in the consumption of fuel, and in the case of water-gas, the costs include the addition of carbylamin or other substance to give the gas an odour. Carburetting is carried far enough to bring the gas to 16-candle standard. Costs are given in pfennigs.

	Calories per cub. m.	Efficiency in per cent.	Cost of Fuel. Per cub. m.	Cost of Fuel. Per 1,000 calories	Cost of 1,000 candle-hours. Batswing burner.	Cost of 1,000 candle-hours. Welsbach burner.
Humphrey and Glasgow's Process.						
Pure water gas	2,500	55	1·77	0·71		3·54
Do. carburetted with German oil	5,000		4·00	0·80	37·5	7·4
„ „ „ foreign oil	5,000		6·2	1·24	57·0	11·0
Dellwik's process.						
Pure water gas	2,350	51	1·66	0·71		3·48
Do. carburetted with German oil	5,000		4·21	0·87	40	7·7
„ „ „ foreign oil	5,000		6·32	1·28	60	11·6
„ „ „ benzoline ...	3,700		4·62	1·24	44	8·5
Strache's process.						
Pure water gas	2,500	35	2·24	0·90		4·48
Do. carburetted with German oil	5,000		4·47	0·90	42	8·81
„ „ „ foreign oil	5,000		6·67	1·32	63	11·4
„ „ „ benzoline ...	3,700		5·20	1·40	49	9·4
Coal Gas.						
Without bye-products	5,000	33·5				
With „ „	5,000	66	1·9	0·38	17·8	3·4
Mixed Coal and Water Gas	3,670		2·35	0·64		4·25
Dowson Gas	1,250	70	0·51	0·44		

As regards the relative costs of plant, that for Dowson gas is by far the cheapest; for water-gas the cost is about four times as much, and for coal gas is slightly higher than for water-gas. The cost of labour is about the same in water-gas and coal-gas installations, while for Dowson gas it is somewhat lower.

The author concludes as follows:—For power purposes, Dowson gas is by far the best, being more efficient, simpler, and cheaper in cost of plant. For industrial purposes, where a high temperature is required, water gas has the advantage. For town lighting, carburetted water-gas can compete with coal gas only in very small installations, and where bye-products are unsaleable; it can, however, often be of advantage as an auxiliary plant to a coal-gas installation. G. H. B.

1379. *Mathot Indicator.* (Locomotion Automobile, 8. pp. 135–136, Feb. 28, 1901.)—A pressure indicator is described, designed by R. Mathot, applicable to high-speed petrol engines. It is identical in principle with the ordinary diagram indicator except that the "card" is a continuous strip of paper passed round the drum by means of clockwork. The piston of the indicator actuates a moving pencil, and a fixed pencil traces the line of atmospheric pressure. The cylinder of the indicator is water cooled. The diagram shows the number of explosions during any given number of revolutions, their pressure, and the pressure of compression when an explosion is missed. With a light spring the back pressure and partial vacuum on exhaust and suction are clearly shown. Some interesting diagrams from a "BG" motor at speeds up to 800 r.p.m. are given. C. R. D'E.

AUTOMOBILISM.[1]

1380. *Milwaukee Steam Truck.* (Horseless Age, 7. pp. 56–59, Feb. 6, 1901.)—The most noticeable feature of this truck is that it is fitted with solid rubber tyres, although the carrying capacity is 4,000 lbs. Its own weight is not given, but the tyres are 4 inches wide and are of that type in which blocks of rubber protrude from an inner cushion through spaces in a steel rim. The idea of the makers is that it is cheaper in the long run to renew the tyres when necessary than to subject the machinery to detrimental vibration, or to sacrifice the speed of the venicle; they also consider that the road conditions are such in America as to render steel tyres troublesome. The truck is 11ft. 7½in. long by 6ft. 3in. wide, the platform for carrying the load is 8 feet long by 6 feet across, the wheel base is 6 feet, and the wheel track 4ft. 8½in. between tyre centres; it can turn in a circle of 29ft. 6in. diameter. The framing, reach bars, and other parts subject to excessive twisting strains, or working chiefly in compression, are all made of seasoned oak. The rear axle, which is an unbroken truss tube carrying the differential gear on sleeves, is supported in bearings both inside aud outside the road wheels—four springs and reach bars holding them in place. The front axle is a steel forging which is embedded in oak on the compression side, and at the ends of which the axles of the steering wheels are pivoted. The two axles are connected by reach bars, and the rear axle is connected to the platform by long inclined radius bars, which are attached to the axle by eccentrics so as to allow of adjusting the driving chain. Wooden wheels are used. Plain bear-

[1] Electric Automobiles are described in the section dealing with Electric Traction.

ings, with thrust collars where necessary, are employed throughout. A foot brake acts upon the differential gear box and a screw hand brake works equally upon both rear tyres. A horizontal wheel with a worm-gear serves for steering, and a block chain in lieu of rods allows a larger turning arc to be obtained. Water tanks with a capacity of 550 lbs. are placed above the driving axle, and a kerosene tank holding 170 lbs. of oil is fixed behind these; this quantity of water serves for running about 20 miles, and of oil for 60 miles. A triple cylinder, single-acting vertical engine is fixed at the back of the driver's cab, partly above and partly below the platform. The valves are of the poppet type, and are operated by cams which allow of varying the cut-off in the cylinder and of reversing the engine. The cam shaft slides longitudinally in its bearings, and thus brings the different cams into operation as required. The lift of the valves is $\frac{1}{8}$ inch. Power is transmitted from the engine to a countershaft by either of two sets of gears; the one has a speed ratio of 4 to 1 and the other of 11 to 1. A positive clutch, which can only be moved when the engine is at rest, brings either of these gears into play, and gives a normal speed to the truck of either 10 or 4 miles an hour. The final drive, from the countershaft to the rear axle, is made by means of a central chain. The boiler is of the ordinary fire-tube type, with 150 square feet of heating surface and a normal working pressure of 225 lbs. per square inch. Two single nozzle burners, using "heavy kerosene," supply the necessary heat. Drawings of a similar truck, also designed by W. L. Bodman, accompany the description; in these drawings the load is given as 3,000 lbs., the engine speed as 550 r.p.m., the two speeds as 12·8 and 5·1 miles per hour, and the fuel tank capacity as 22 gallons. A. G. N.

1381. *The Hautier Petrol Car.* (Locomotion Automobile, 8. pp. 102–105, Feb. 14, 1901.)—This vehicle is fitted with motors of either $4\frac{1}{2}$, 7, or 12 h.p., which are known by the name "Espérance." The peculiarity of the motor is that the combustion chamber is formed in two parts, and a valve is fitted in such a way that it can be made to close all communication between them when so desired while the motor is working. The object of this device is to more nearly approach the conditions of a variably timed ignition device while still using some form of tube ignition. At starting, and when the motor is running slowly, the valve above mentioned is allowed to remain open; the size of the combustion chamber is then such that the degree of compression is somewhat less than that now normally employed in other motors. When the speed is increased, and an even higher speed is desired, the valve is closed, and, the compression being thus considerably increased, ignition occurs earlier. Another feature of this motor is the exhaust valve gear, in which a specially shaped cam causes a lever to rock backwards and forwards about the axis of a spindle to which it is fixed. The movement of the lever alternately opens each of the exhaust valves, and the degree to which they are lifted is variable. The general arrangement of the propelling mechanism is similar to that of Darracq [see Abstract No. 555 (1901)], and many others, but the change-gear wheels remain always in mesh, and an epicyclic train replaces the ordinary clutch, between the motor and the gear case; the last-mentioned device has one of its members mounted so as to revolve freely normally, and a band brake is used to retard it progressively and to hold it ultimately—thus establishing a rigid connection between the motor and the gearing gradually. Several illustrations accompany the description.

A. G. N.

1382. *Municipal Motor Vans.* (Automotor Journal, 5. pp. 236–237, Feb., 1901.)—In a report made by the surveyor to the city borough of Westminster the following information is given concerning a Thornycroft steam waggon which has been in use in the Strand district. For the first eight weeks the motor was on hire from the makers at a total cost, including fuel and labour, of £7 10s. per week. During this time it was used for dust collection only, and it dealt with 152 loads, comprising over 252 tons. The vehicle was then purchased, and two bodies (tipping and watering) were supplied with it. During the following seven weeks 153 loads, weighing nearly 364 tons, were removed by it, and its consumption of Nixon's navigation coal was 9 tons. In an ensuing period of seven weeks it was also used for street watering, the body being changed each day and night. During this time it collected 87 loads of dust, of a weight of 189 tons, it distributed 225 loads of water (157,500 gallons) in the daytime, and 777 loads (543,000 gallons) for flooding the streets at night. The coal consumption in this third period of working was 12 tons. It is pointed out that house dust is very light, and that its weight does not convey a correct idea of the labour involved in its collection; the yearly average for the Strand district, exclusive of street or market sweepings, is 1,265 tons per mile of street, whilst the bulk is 4,216 cubic yards. For this reason, and because experience has shown the especial economy of steam power for the heavier traffic, the use of a trailer is strongly urged for dust waggons. Concerning the relative cost of working during the above-mentioned periods, an estimate of the annual saving which would be effected by the employment of this machine is given in detail, and amounts to £772. A further estimate of the annual expenditure necessary in respect of the motor places this amount at £598 8s. A. G. N.

1383. *Metropolitan Motor Manufacturing Co.'s Voiturette.* (Automotor Journal, 5. pp. 260–261, March, 1901.)—A two-seated carriage in which the body, the motor, and the speed-gearing are carried by an angle-iron rectangular frame, which is itself suspended upon the front steering-wheel axle and the "live" driving axle by semi-elliptical springs. Ackermann steering is used, and the rear axle runs in Mossberg roller-bearings. The motor is placed across the front of the frame; it consists of two separate vertical cylinders 3½-inch bore by 6-inch stroke, which are each provided with a crank chamber containing an overhung crank-pin on the end of a short projecting crank-shaft. The two crank-shafts are coupled together, and carry a central flywheel with a pulley on either side of it. A cam-shaft mounted above the cylinders is driven by bevel gearing, and operates the two exhaust valves and the contact breakers for the ignition device. The cylinder covers, which are easily removed, contain the inlet and exhaust valves, as also the ignition plugs and compression relief cocks. A counter-shaft is provided across the centre of the frame, and carries a rocking gear-case which encloses two opposite and eccentrically mounted pinions and concentric intermeshing spur wheels. Each of the short shafts carrying the pinions projects from the gear-case, one on each side, and each of them is fitted with a pulley. A pair of 2¼-inch belts connect these pulleys with those upon the motor shaft, and both the belts are normally slack. By rocking the gear case about the countershaft either belt can be tightened, and the power from the motor can thus be transmitted to the countershaft by either pinion. The two pinions are of different diameters, and thus either of two speeds can be obtained. A chain connects the counter-shaft with a differential gear on the rear axle.
A. G. N.

1384. *Heavy Motor Traffic in France.* (Horseless Age, 7. pp. 26–29, Dec. 26, 1900, and 26–28, Jan. 2, 1901. Abstract of a paper read before the Liverpool Self-propelled Traffic Association by **G. Forestier.**)—A review of the progress of motor vehicles for passenger and for goods transport in France since the "Poids lourds" trials of 1897. Dealing firstly with passenger vehicles, the author points out the general tendency towards increase of power per person carried in order to secure a high commercial speed and greater number of journeys per day. For example, the de Dion and Bouton steam omnibus, in the 1897 trials, with a weight of 5 tons empty and 6·7 tons carrying 16 passengers, had an average speed of 8·6 miles per hour. In the 1900 trials, a vehicle of the same construction weighed 6·6 tons empty, 8·6 tons carrying 20 passengers, and had an average speed of 11·2 miles per hour. The estimated cost per traveller per mile with luggage, ten persons being reckoned to the ton, has diminished as follows :—

In 1897	0·48d.
In 1898	0·24d.
In 1899	0·23d.

These calculations do not, however, make any allowance for damage done to the roads. Passenger vehicles propelled by internal combustion engines possess certain advantages over steam-propelled vehicles, but owing to the power of the engine being practically constant, any increase in the tractive resistance has to be met by decreasing the speed of the vehicle. The fact that only one person is required to drive and control the vehicle reduces the working expenses, but cost of fuel is much greater than with steam power. Taking the cost of coke at 29s. 6d. per ton and petrol at 1s. 6d. per gallon, the results of the trials at Versailles work out 0·91d. per net ton-mile for fuel with a coke-fired boiler and 3·15d. with a petrol engine.

Electrically propelled vehicles have competed in the "Poids lourds" trials since 1898 with some success, and have been in practical use in Paris, but in most cases the useful load forms a very small proportion of the total weight, and the distance that can be travelled per charge is small. The supply of current to electrical vehicles from a motor trolley travelling on an overhead cable promises a solution of the difficulty in certain cases [see Abstract No. 588 (1901)].

With regard to vehicles for the delivery of goods the figures given in the following table have been deduced from the "Poids lourds" trials :—

Date.	Maker.	Type.	Freight.	Total Weight.	I.H.P.	Speed.
			Tons.	Tons.		Miles per hr.
1897	Scotte	Lorry, with single trailer	4·1	11·6	16	4·0
1898	De Dion & Bouton	Lorry	3·2	8·7	30	7·1
1899	Ditto	Ditto	3·9	9·7	30	9·2
1900	Ditto	Ditto	2·3	7·5	28	8·2

As in the case of passenger vehicles, the weights and speeds are such that the damage done to the road surfaces must be considerable. The author points out that as the carrying capacity with a given engine power decreases with increased speed, the net ton-miles per day will be very considerably reduced if the speed is excessive, and the wear and tear on vehicle and road

much increased, so that for the most economical working, moderate speeds must be maintained.

For the transport of moderate loads the petrol lorries of de Dietrich and others have given very good results. Particulars of some of these vehicles are given in the following table :—

Date.	Maker.	Type.	Freight.	Total Weight.	I.H.P.	Speed.
			Tons.	Tons.		Miles per hour.
1897	De Dietrich	Lorry.	1·2	2·5	6·5	5.3
1898	Ditto	Ditto	1·5	3·3	9·0	6·7
1899	Ditto	Ditto	2·3	4·1	9·0	6·6
1900	Ditto	Ditto	3·0	4·8	9·0	7·6
1900	Panhard and Levassor	Ditto[1]	2·0	4·4	8·0	7·4
1900	Peugeot	Ditto[2]	1·2	2·4	8·0	8·3

[1] Solid rubber tires on steering wheels. [2] Solid rubber tires on all wheels.

An interesting electrically propelled lorry has recently been built for the Say sugar refinery of Paris ; it weighs with accumulators, but unladen, 11·8 tons, and carries a load of 10 tons. The motor is rated at 20 h.p., and at the Vincennes trials of 1900 the average speed was 3·3 miles per hour, and 2·0 m.p.h. up an incline of 10 per cent., the motor then taking 200 amps. at 155 volts. With regard to cost of working, the author considers that the usual rating of 10 per cent. to 15 per cent. of the prime cost for maintenance and repairs is too low, and that 25 per cent. would be a safer estimate for practical working. The following results have been deduced from the "Poids lourds" trials :—

Cost per Passenger Mile, including Luggage, or per Two Cwts. of Parcels per Mile. (In decimals of One Penny.)

	Third-load.	Half-load.	Fully Laden.
Steam.			
De Dion and Bouton omnibus—			
1900.....22 seats.....	0·46	0·24	0·14
De Dion and Bouton brake—			
1897.....35 seats.....	0·67	0·34	0·23
1898.....55 „	0·43	0·22	0·15
Serpollet omnibus—			
1898.....14 seats.....	0·93	0·50	0·34
Scotte omnibus—			
1897.....26 seats.....	1·10	0·57	0·39
Gasoline.			
Panhard and Levassor omnibus—			
1900.....14 seats.....	0·90	0·46	0·34
Rozer-Mazurier omnibus—			
1898.....14 seats.....	1·05	0·52	0·37
De Dietrich brake—			
1898.....10 seats.....	1·06	0·49	0·34
1899.....10 „	0·78	0·42	0·30

GOODS—COST PER NET TON-MILE. (In Pence.)

	Third-load.	Half-load.	Fully Laden.
STEAM.			
Scotte train (1897)	9·29	4·82	3·36
De Dion and Bouton lorry—1900	4·09	2·18	1·52
GASOLINE.			
De Dietrich lorry—1900	6·13	3·42	2·49
Panhard and Levassor lorry (1900)	6·39	3·65	2·64
Peugeot lorry (1900)	6·98	3·95	2·93

In conclusion, the author compares the cost of motor transport in France with the cost by railway and by horse; and calls attention to the chief items in the road maintenance question. C. R. D'E.

1385. *Collin's Electric Vehicle Company's Steering Gear.* (Locomotion Automobile, 8. pp. 137–138, Feb. 28, 1901.)—This article describes a form of steering gear which combines the old locking-plate method of steering by turning the front axle, with the usual form of pivoted axles for the steering-wheels. The construction is very complicated, but possesses the features that a very small movement of the hand suffices for describing curves of small radius, and that the controlling action is irreversible. C. R. D'E.

1386. *Diameter of Wheels for Autocars.* **W. A. T. Müller.** (Centralblatt Accumulatoren, 2. pp. 89–93, March 15, and 105–108, April 1, 1901.)—This article, which is mainly of an elementary mathematical nature, continues the discussion of the question already dealt with by Luxenberg. [See Abstract No. 587 (1901).] The author starts by considering the formula $P = Q\frac{f}{r}$, where P is the tractive force on the vehicle, Q is the load, r is the radius of the wheel, and f is the so-called leverage of rolling friction. This latter quantity may be defined as the horizontal distance between the resultant vertical pressure exerted by the ground on the wheel and the vertical through the centre of the wheel. Luxenberg treats f as though it were constant, and independent of the size of the wheel; Müller, however, considers that this is not the case, and that f increases with the radius of the wheel. The author deals in his article with the case of a vehicle having rigid wheels, which roll on an elastic roadway; and he assumes that the pressure at any point on that part of the surface of the tyre which is in contact with the roadway is proportional to the depth of the depression caused at that point. He then shows that the resistance due to rolling friction is proportional to the square of the depth of the depression caused on an elastic roadway, and arrives ultimately at the following formula, viz.—

$$W = c\sqrt[3]{\frac{Q^4}{br^2}}$$

where W is the resistance due to rolling friction, Q is the load, b is the

breadth of the tyre, r is the radius of the wheel, and c is a constant depending on the nature of the roadway and the material of which the tyre is made. Hence for a given load W is inversely proportional to $\sqrt[3]{r^2}$, whereas Luxenberg states that it is inversely proportional to r, and Zechlin says it is inversely proportional to $\sqrt{r}$. The author concludes with a few numerical examples and considers that if accumulator traction on ordinary roads without rails is to be a commercial possibility, a type of car will have to be designed on lines altogether different from those on which omnibuses and such-like vehicles have been constructed in the past. He speaks of wheels having a diameter of 2·5 m., and with these he thinks that it is possible to attain an efficiency represented by 50 watt-hours per ton-kilometer. W. H. S.

REFERENCES.

1387. *Theory of Heat-Engines.* **A. Witz.** (International Physical Congress at Paris, Report, 3. pp. 296–305, 1900.)—A short account of recent *experimental* theories of the steam-engine, including the work of Boulvin and of Nadal, is given, and the need of similar work for the more complex case of gas-engines is urged. R. E. B.

1388. *Double-Tube Boiler.* **J. Irving.** (Engineering, 71. pp. 474–475, April 12, 1901. Paper read before the Institution of Naval Architects.)—This is a description of a horizontal water-tube boiler with concentric fire tubes, which gave fairly good results on trial. F. J. R.

1389. *Thornycroft-Marshall Water-Tube Boiler.* (Mech. Eng. 7. pp. 550–553, April 20, 1901.)—A description of this form of horizontally inclined water-tube boiler in both "non-sectional" and "sectional" designs with illustrations, and photographs showing the method of constructing a non-sectional boiler.

GENERAL ELECTRICAL ENGINEERING.

1390. *New Primary Batteries.* **A. Reynier.** (Électricien, 21. pp. 86–89, Feb. 9, 1901.)—Two cells, due to Fontaine-Atgier, are described. One is a simple element, consisting of iron and zinc in caustic soda solution; the depolarisation, which appears to be efficient, is mechanical, and is effected by having the iron in the form of gauze. The e.m.f. is about 0·45 volt. The other cell is of the two-fluid type, consisting of zinc in caustic soda separated by a porous pot from carbon in a nitric depolarising solution (of secret composition). The e.m.f. may be as high as 2·5 volts, and the depolarisation is good. The porous pots are made of perforated ebonite or celluloid surrounded by pasteboard. W. R. C.

1391. *Utilisation of Lead Slime and Old Plates.* **E. Levermann.** (Centralblatt Accumulatoren, 2 pp. 53–54, Feb. 15, 1901.)—Lead slime—a mixture of lead peroxide, lead sulphate, and sulphuric acid—is best treated by washing with water to remove acid, decomposing the lead sulphate with soda, removing the lead carbonate thus formed by washing with acetic acid, and drying the residue at 180°. The lead peroxide thus obtained may be used for such purposes as match-making, &c., where absolute purity is not essential. Old plates may be sent direct to the smelting works, but it is sometimes better to separate the active material, which may be either remelted or used for forming new plates, and to recast the grids. N. L.

1392. *Meters of the Allgemeine Elektrizitäts Gesellschaft.* **M. Aliamet.** (Électricien, 21. pp. 81–86, Feb. 9, 1901.)—Two meters are described with numerous illustrations. The first, for continuous currents only, consists of an electro-dynamometer, the main current passing through the fixed coil and the shunt current through the moving coil; the latter is caused to oscillate between fixed limits by an automatic commutator; the rate of oscillation is directly proportional to the power, and the number of oscillations is registered by a ratchet acting on an indicating train. The commutator consists of four contacts, two in a double-magnet relay, and two actuated by the moving coil. The shunt current passes through one relay magnet, two resistances, and then the second relay magnet; the terminals of the moving coil are attached, one between the two resistances and the other to the two contact fingers. The current passes in parallel through the moving coil and one or other of the resistances, according to which contact is made by the relay, the direction of current being different in the two cases; the relay is thrown over by the moving coil, at the end of its throw, making a contact which short-circuits the relay magnet and the resistance; this demagnetises one relay magnet and increases the current in the other, which then pulls over the relay contact; this process is repeated alternately in each direction. The meter starts with 1 per cent. of its maximum current. The shunt circuit absorbs 1·2 watts at 100 volts. Readings are correct at 90 per cent. load and 6 per cent. load, with an intermediate maximum error of 1½ per cent.; at 2 per cent. load the error is ½ per cent. in the opposite direction.

In the second meter, for alternate currents only, three electromagnets,

with a common yoke, act on one side of a copper disc, the magnetic circuit above the disc being completed by an iron bar facing the three poles. The shunt current traverses the first and third magnets; if the iron bar be inclined, so that the air gap of one magnet is greater than that of the other, rotation of the disc will ensue, owing to inequality in the two induced currents. This fact is employed as a means of compensating internal friction, the inclination of the iron bar being adjusted till the meter just does not run on the shunt circuit alone. The main current traverses the first and second magnets, this second magnet serving as compensator for the want of proportionality between magnetic flux and current. The meter does not read correctly on an inductive load. On a non-inductive load the error does not exceed 1 per cent. down to 5 per cent. of maximum load. The starting current is 1 per cent. of the maximum, and the power absorbed is 1 watt in the shunt circuit and 2 watts in the main circuit at full load.

G. H. B.

1393. *Raymond's Automatic Time Switch.* **G. Dary.** (Électricien, 21. pp. 161–162, March 16, 1901.)—In this apparatus, there is a crown-wheel driven by a clock, and on this wheel are secured two curved arms which can be clamped thereto by means of a lock-nut so as to project from the side of the wheel at any desired angle apart. These arms drive a star-wheel on an arbor bearing a second star-wheel of insulating material. This second star-wheel has a metal plate secured on one or more of its faces and connected through a fixed spring contact to one end of the interrupted circuit. The other end of the circuit is connected to a contact piece mounted on a spring, which presses it against the star-wheel. By this means the circuit can be made and broken for any desired period or periods in the twenty-four hours. This apparatus is in use for controlling the illumination of advertisement kiosks at Lyons and Saint-Étienne. C. K. F.

1394. *"Armacell" Insulating Varnish.* (Elect. Engin. 27. pp. 190–191, Feb. 8, 1901.)—A varnish must be (1) insulating; (2) must not soften with heat; (3) not fall off in insulation with heat; (4) be flexible; (5) adherent to all materials used in electrical construction. Results are given of tests of paper coated with "Armacell." M. O'G.

1395. *Cleanliness of Porcelain Insulators.* **G. Pierard.** (Soc. Belge Élect., Bull. 18. pp. 71–72, Feb., 1901.)—After use, a number of insulators were cleaned and tested in comparison with the dirty ones; with deep petticoats the falling off was from 4,400 to 3,400 megohms. Small insulators fell off from 6,800 to 1,800 megohms. M. O'G.

1396. *Siemens and Halske High-Tension Safety Device.* **H. Görges.** (Elektrotechn. Zeitschr. 22. pp. 310–311; Discussion, p. 311, April 4, 1901. Paper read before the Elektrotechn. Verein, Dec. 18, 1900.)—This paper describes a device of the spark-gap type, intended to prevent accidental shocks arising from defective insulation in transformers and such apparatus. It consists essentially of a plug and socket, the plug containing two metallic portions which are separated from one another by a thin sheet of mica, pierced with holes. By inserting the plug in the socket the necessary contacts are made and if the voltage rises to a dangerous degree, the discharge passes through the holes in the mica sheet. The discussion seemed to show that the device (of which a drawing is given) is at present rather uncertain in its action.

W. H. S

1397. *Starting Resistances for Motors.* **P. Bunet.** (Ind. Élect. 10. pp. 103–107, March 10, 1901.)—Assume that the resistance is to allow a current I to flow when the switch is on the first contact, and that after the current has fallen to i the switch is moved to the second contact, when the current is to rise to I again, and so on. Then, if R is the resistance of the motor, and

$$R_1 = R + \text{resistance of starter on first contact},$$
$$\text{and } V = \text{voltage of mains},$$
$$\text{then } I/i = R_1/R_2 = R_2/R_3 = \&c.$$
$$\text{Thus } R_1/R = (I/i)^{n-1},\ n \text{ being the number of contacts.}$$
$$\text{Or, since } R_1 = V/I,\ n = \frac{\log V/I - \log R}{\log I/i} + 1.$$

The writer shows that, in cases where the torque opposing the motor is independent of the speed, the times during which the switch is left on successive contacts in starting should, like the resistances, decrease in geometrical progression. In automatic starters the contacts may be made of decreasing width to secure the above condition. Various numerical cases are given.

For a resistance made of round wire it is proved that the volume is proportional to the cube root of the specific resistance of the metal used, assuming that heat emissivity and final temperature are the same in each case. On the other hand, if the current is only allowed to pass for a short time, the heat generated being assumed to be all taken up by the wire, then the volume is independent of the specific resistance. W. H. E.

1398. *Electric Travelling Cranes.* **A. Kolben.** (Elektrotechn. Zeitschr. 22. pp. 148–154, Feb. 14, 1901.)—In all the latest cranes there are three separate motors, one for each motion. They are mostly four-pole direct current, or else induction motors. Worm gearing is used for reduction from the motor speed, and in some cases is combined with toothed gearing. For taking up the axial pressure of the worm, collars with ball bearings are employed. The usual pitch-surface velocity of the worm is from 5 to 6½ metres per second. The worm wheel consists of a phosphor-bronze toothed ring mounted on a steel casting; the worm is of hardened steel. A brake is required for the lifting drum and, in quickly-moving cranes, on the traveller also. The weighted brake is held off by the pull of a solenoid, the plunger of which may be designed so as to leave a partial vacuum below it when raised, thus overcoming residual magnetism when the current is switched off. An emergency brake is worked by the driver's foot; and the worm gearing, by its non-reversibility, is an additional safeguard. The paper, which is well illustrated, deals specially with cranes made by the Elektricitäts Act. Gesellschaft, formerly Kolben & Co., of Prag-Vysocan. W. H. E.

1399. *Electric Cranes.* **P. Uellner.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 289–297, March 2, 1901.)—A description is given of several cranes recently made by the Compagnie Internationale d'Électricité. A traveller for an iron-works has a span of 13 metres, and the following speeds: for a load of 22 tons, 2·5 metres per minute; for 2 tons, 20; for the crab, 25 to 30; for the crane, 80 to 90. A separate motor is provided for the 22-ton hook and the 2-ton. The motor for the crab is 6 h.p., and the three others are 15 h.p. each, with a speed of 950 r.p.m. Toothed gearing is used throughout, the speeds being high enough to render this convenient instead of worm gearing.

The leather pinion of the motor drives a cast-iron wheel engaging a wrought-steel pinion geared with a cast-steel wheel; for the 22-ton hook there is an additional pinion and wheel. The speed ratio for each pair is 4 or 5 to 1. The 2-ton hook, on account of its speed, is controlled by a specially powerful electric brake, and great care had to be taken in designing the guides for the quickly moving chain. Tests of the crane gave the following results for the four motions :—

	Load (tons).	Speed. m./mn.	E.H.P.	Efficiency per cent.
Large hook	0	2·3	6·7	—
	23	2	16	64
Small hook	0	26	7·35	—
	2	20	12·7	70
Crane	0	96	9·7	—
	23	60	16·8	—
Crab	0	32·5	2·9	—
	23	28·5	6·7	—

The tractive force required for the crane was 25·5 kg. per ton, and for the crab 24.

In another travelling crane a special arrangement is used to enable the load to be raised exactly vertically by means of one rope wound on one drum. The upper block of the lifting tackle swivels on ball bearings so as to be always in the same plane as the rope which winds on or off the drum. The pulleys in the lower block must have a radius greater than half the length of the drum. A wire rope is used, 14·5 mm. in diameter, and having a breaking load of 6,050 kg. With four ropes in the tackle the factor of safety is 6.

The efficiency at full load of 4 tons, raised 4 m. per minute, is 71 %.

In this traveller all three motors are provided with electric brakes, which come into action on switching off the current, and thus facilitate accurate placing of the load.

The paper also gives a description, with drawings, of some powerful cranes supplied for handling blocks of stone in quarries. Each consists of a lattice-work girder fixed on trestles which run on rails; and a lifting crab travels over the length of the girder. The largest one can lift 60 tons.

W. H. E.

1400. *Electricity in Machine Shops.* **F. R. Jones.** (Engineering, 71. pp. 287–288, March 1, and 320–321, March 8, 1901. Paper read before the Amer. Soc. Mech. Engineers.)—After discussing the conditions to be fulfilled, the author decides in favour of direct-current supply at 220 and 110 volts on the three-wire system as most suitable for power and lighting. Experiments showed that two lathes, when polishing columns 10 and 12 inches diameter, together required 7 h.p.; two planers, with tables 6 feet and 10 feet wide, driven by one motor, took up to 60 h.p. when both were reversing at once; a planer, with a table 5 feet wide, took 25 amperes when cutting, and 45 amperes when reversing, at 230 volts; three 30-ton four-motor cranes took up to 100 h.p. each as a maximum when all the motions happened to be in operation simultaneously. Full details of the results of these and other tests are given. The conclusion is that three independent circuits are necessary—a crane circuit, for the most irregular loads; a machine-tool circuit for the steadier loads; and a lighting circuit.

Two large generating sets for the power circuits, and a smaller one for lighting, are recommended, and a motor generator for balancing. The author advocates the use of pneumatic hoists and electric locomotives for handling materials in the works and yards. Experiments made in two large works before the adoption of electric driving showed that half the average power of the engines was wasted on friction. The paper concludes with a strong argument in favour of portable tools driven by electric motors, mainly based on the saving of time in setting the work in position. A. H. A.

1401. *Electric Power in Workshops.* (Frank. Instit., Journ. 151. pp. 1–28 (Jan. 1901 ; Discussion.)—**F. B. Crocker,** in opening a discussion on this subject, stated the advantages of electric driving under the following heads : (i.) *Saving of Power.* This is considerable, but relatively unimportant, the total cost of power in factories being only 1 to 3 per cent. of the total expense. (ii.) *Cheaper Buildings,* because lighter owing to absence of overhead shafting. (iii.) *Smaller Depreciation.* (iv.) *Flexibility* as regards arrangement of machines conveniently, and extensions. (v.) *Clear Head-room,* permitting overhead travellers anywhere. (vi.) *Cleanliness.* (vii.) *Healthiness.* In the Government printing offices in Washington, one of the largest in the world, the sick list decreased 20 to 40 per cent. after introduction of electric driving. (viii.) *Shut-downs less serious and less frequent.* (ix.) *Speed Control.* (x.) *Increased Output,* chiefly owing to advantages (v.) and (ix.).

S. M. Vauclain, superintendent of the Baldwin Locomotive Works, stated that "if we should abandon electric driving, our manufactured product would now cost from 20 to 25 per cent. more for labour," and that "were it not for electric driving the Baldwin Locomotive Works would have to cover 40 per cent. more floor space than they now do, to maintain their present output."

G. S. Dunn stated that on the assumption of constant torque and capacity limited by commutation, the limits of successful speed control through the agency of the motor's field are at the extremes of a range of about 33 per cent. increase above a minimum speed. This requires a motor of which the capacity calculated at minimum speed would be about $33\frac{1}{3}$ per cent. greater than the h.p. demanded at maximum speed, or about 76 per cent. greater than the h.p. demanded at minimum speed. A given motor, of which the normal speed is the minimum desired, must not be called upon at maximum speed for an output greater than its normal capacity multiplied by the ratio of the minimum speed to the maximum. The speaker referred to the "multiple voltage" and "Ward-Leonard" systems of speed control. The drawback to the latter is high first cost, but maintenance is low.

W. H. Tapley, of the Government Printing Offices, gave data concerning their motor-plant during the past five years. The generating station contains three units aggregating 612 kw., and there are 200 motors totalling 854 h.p., as well as 5,000 16-c.p. lamps and an average of 70 amps. used in heating 10 press-heads. The average demand is 1,500 amps. at 120 volts, and the ratio of maximum demand to h.p. connected is 1 : 3·5 under average conditions. The saving on coal and gas bills was a clear 10 per cent. after allowing $6\frac{3}{4}$ per cent. on cost of plant for insurance, taxes, and interest. The increase in production for presses was 10 per cent.

C. Hering advocated the use of the multiphase induction motor for workshops. It is easily started at full load (the larger ones requiring for this purpose some simple slide-rings) ; it runs at nearly constant speed and stands

considerable overload. No satisfactory method is yet known for varying its speed without impairing its efficiency. It is smaller, lighter, simpler, and cheaper for the same output and speed than the continuous-current motor.

G. S. Dunn differed absolutely from the last speaker. Ordinary constant-speed induction motors of the kinds built in America do not develop at starting more than from $1\frac{1}{2}$ to 2·2 times their normal running torque, whereas direct-current motors will easily develop in starting from 4 to 6 times their normal running torque. Recent American quotations from companies making both classes of motors have been about 25 per cent. higher for alternating-current motors. The wear at commutators is now very slight ($\frac{1}{64}$ inch of commutator and $\frac{3}{8}$ inch of carbon brush per annum). The extremely small air-gaps of induction motors necessary for keeping down wattless current causes serious trouble by accumulation of dust. The induction motor requires an enormous starting current, and its torque varies as the square of the voltage; consequently the starting up of one motor may reduce the torque of another motor sufficiently to make it lose its grip and stop. For this reason induction motors are being thrown out of a colliery.

C. Hering concluded from the last speaker's remarks that induction motors are more developed in Europe than in the United States. His remarks as to relative costs, weights, &c., were based on statements of a German company manufacturing both direct-current and induction motors. The cosine of the angle of lag of their motors is over 0.9, and the wattless current is therefore small. They will stand 200 per cent. overload, and will still give their normal output for two-thirds the normal voltage. The starting current can be kept down to the normal. E. H. C.-H.

1402. *Electric Power in Factories.* **W. Geipel.** (Elect. Rev. 48. pp. 340–342, Feb. 22, and 381–383, March 1, 1901 Paper read before the Gloucester Engineering Society, Feb. 19, 1901.)—Older methods fall under three heads—(i) Works driven by one large engine with shafting; (ii) works driven by scattered engines supplied from central bank of boilers; (iii) works driven by scattered engines and boilers.

In class (i), the engine should already be of the compound condensing type and efficient, but the losses in shafting are rarely as low as 20 per cent. At the Bristol Waggon Works the loss varied between 22 and 57 per cent. At the Hartlepool Engine Works, Middlesbrough, it ranged from 75·6 per cent. to 42 per cent. In the U.S.A., C. H. Benjamin made exhaustive tests on shafting losses in various factories, and his figures vary between 14 and 81 per cent. He found that the average h.p. lost per bearing was 0·5 h.p., per 100 feet of shafting 6 h.p., per 100 lbs. of shafting 0·25 h.p., and per belt 0·4 h.p.

In class (ii), steam may be economically generated by a central bank of boilers, but it is transmitted through long lengths of pipe to small uneconomical engines. The loss from condensation in steam-pipes amounts to $\frac{1}{2}$ ton of coal per annum per square foot of uncovered pipe, if continually under steam and exposed to the atmosphere; with the best lagging this figure becomes $\frac{1}{8}$th ton per annum. Small scattered engines are usually low-pressure, non-condensing. Bryan Donkin tested 100 such engines taken at random, and found the average consumption to be 150 lbs. of steam per i.h.p. per hour. T. Richardson found the average for 31 engines in his Hartlepool Works to be 51 lbs. per i.h.p. per hour.

Class (iii) is obviously expensive as regards coal bill and labour.

With electric driving the losses may be taken as follows: Motors, 8 per cent. (100 h.p. size) to 25 per cent. ($\frac{1}{3}$ h.p. size); generators, 8 per cent.; con-

ductors, 2 per cent., giving a total efficiency of 76 per cent. Allowing 10 per cent. for engine friction, we thus have 68 per cent. of the engine i.h.p. at full load delivered to the motor-shaft, or about 60 per cent. at half load. The introduction of electric driving has been found to increase the output of the works by about 20 per cent., and the facilities for dealing with heavy material are much greater. E. H. C.-H.

1403. *Electrically Driven Machine Tools.* **G. Ralph.** (Inst. Elect. Engin., Journ. 30. pp. 545–560; Discussion, pp. 560–566, April, 1901.)—The author discusses the advantages of electrically driven machine tools. He found that 100 feet of 2½-inch shafting running at 150 revs., to which 24 machines were belted, took to drive it light 45 per cent. of the power necessary when all the machines were in use. In another case of a works with four floors the loss was 56 per cent. In six American shops the average loss was 62 per cent., and in one the loss was 80 per cent. The total h.p. of motors may be double the h.p. of the power station. In the Baldwin Locomotive Works 1,300 h.p. serves 3,100 h.p. of motors. The power required by machine tools is often underestimated by the makers. A grinding machine for trueing up the edges of armour plates, which the makers said would take 6 h.p., was found to take 35 or 40 and occasionally 60. A slab milling machine, which the makers said would take 6 h.p. for a specified depth of cut and rate of feed, actually took nearer 15. This machine eventually had two motors fitted, one to drive the cutter, and the other to drive the feed motion and table. A comparison was made between a slab milling machine with a fluted spiral cutter for heavy work and a machine which was really a cold sawing machine but fitted with a milling or facing head with inserted tools or cutters. It was found that the latter class of milling only absorbs about half the power for a given weight of material removed in a given time. The author describes the application of motors to particular tools. A ¼ h.p. motor mounted on a square steel bar with an emery wheel on the armature shaft is a very useful tool for trueing up the centres of lathes.

Discussion.—**Turnbull** thought the tendency in the future would be to use portable electrically driven tools to save the cost of moving heavy castings and the cost of large tools. **Broadbent** pointed out that in the case of large machine tools it may take two men a considerable time to shift the belt to change the speed, but with a motor driving a single machine the speed can be varied by moving the regulating switch. R. B. R.

1404. *Fire-Alarm Installation at Pforzheim.* (Elektrotechn. Zeitschr. 22. pp. 158–160, Feb. 14, 1901.)—This installation is worked on the system of Mix and Genest, in which the substations are normally connected in series in a closed circuit including, at the central watch station, two Morse recorders, a battery, and an indicating galvanometer, so that, on any fault occurring, indication thereof will be given by the galvanometer and by an electric bell in a local circuit controlled by a relay. The line is also connected to earth at the central station between the Morse recorders through a strong battery, so that, on connecting the line to earth at any of the substations by means of a key, the circuit of the battery at the central station will be closed, an indicator-drop falls, and local circuits, including alarm-bells, are closed by the armatures of the recorders. On momentarily short-circuiting the electromagnet coils of the Morse recorders, a strong current will pass through an electromagnet at the calling-up station, and this electromagnet will release clockwork mechanism driving a commutator or interrupter which will cause

a predetermined set of signals to be sent five times into the line to actuate the Morse recorders at the central station, and at the same time a bell is rung at the substation indicating that the call has been received at the central station. The clockwork, on running down, breaks the earth connection. The keys used to actuate the apparatus at the substations can only be removed by the official who comes to rewind the clockwork. The original paper is illustrated by diagrams of connections and photographs. C. K. F.

1405. *Pelton-wheel Installations.* **G. J. Henry, Jun.** (Journal of Electricity, S. F. 11. pp. 30–35, Jan., 1901.)—This paper gives a description with illustrations of some of the principal installations in the United States of Pelton water-wheels of large size up to 1,650 h.p., and working under heads up to 1,430 feet. G. H. B.

1406. *Cable Estimating.* **R. Appleyard.** (Elect. Rev. 48. pp. 354–355, March 1, 1901.)—It is of use to know the change in weight of the conductor or the change in weight of the dielectric corresponding to a change of one mil. in the diameter of either. If w be the weight in lbs. of unit length of a cylinder of diameter d, $mw = d^2$, where m is a constant. If the change in diameter is 1 mil., the corresponding change in weight at any diameter, d, is given by—

$$w_1 - w_2 = 2d/m.$$

where d is measured in mils. We can tabulate the value of $2/m$ as below for various materials; to make use of this table, multiply the diameter in mils. by the constant, which gives in lbs. per mile of cable the error in weight which would arise from an error of 1 mil. in the diameter.

	Density.	$2/m$ St. Mile.	$2/m$ Nautical Miles.
Gutta-percha	1	0·00360	0·00415
Copper	8·9	0·03206	0·03696
Indiarubber	1·3	0·00468	0·00540
Iron	7·8	0·02809	0·03239
Brass	8·4	0·03026	0·03488

A similar expression might be found for the change in resistance corresponding to one mil. change of diameter, for the resistance is measured by the reciprocal of the weight. M. O'G.

REFERENCES.

1407. *Steam Heating from Central Stations.* **A. D. Adams.** (Elect. World and Engineer, 37. pp. 269–271, Feb. 16, 1901.)—A discussion of the distribution of live and exhaust steam from central electric stations for heating purposes. A. H. A.

1408. *Electricity in Iron and Steel Works.* **S. F. Walker.** (Eng. Mag. 20. pp. 858–876, Feb., 1901.)—Various appliances are here illustrated and described, including furnace-charging apparatus, electromagnetic cranes, magnetic separators, appliances for handling beams, &c.

GENERATORS, MOTORS, AND TRANSFORMERS.

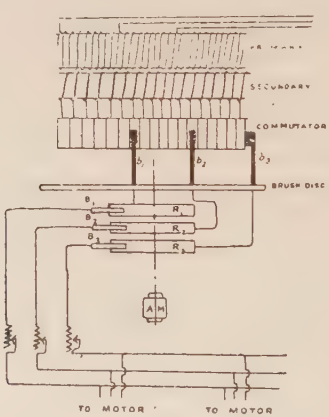
1409. *Windings for Continuous Current Armatures.* **A. Rothert.** (Ecl. Électr. 26. pp. 467–473, March 30, 1901.)—The author deals with toothed armatures wound with wire on formers. With a series or multiple series winding the number of slots may be reduced to one half or one third the number of plates in the commutator, without causing sparking. The turns included between a pair of brushes are spread over the whole surface of the armature, so that a want of symmetry in the magnet field does not matter. With slots 12 to 20 mm. wide and an air space of 3 to 7 mm., either the pole-pieces or the whole magnet must be laminated. The paper includes diagrams showing the arrangement of 2, 3, and 6 coils per slot. With 4 or 8 pole dynamos, with 3 commutator plates per slot, 3 coils can be wound with a single length of wire on one former, leaving two loops, which are afterwards cut, dividing it up into 3 coils. This cannot be done with 6 poles and 3 plates per slot, or 4 or 8 poles and 2 plates per slot. This is for simple series winding; with a double series winding it is just the opposite. In a series winding with a large number of turns, it is not necessary that all the sections should have the same number of turns. For instance a former with three sections may have 3, 4, and 3 turns per section, and the next one 4, 3, and 4 turns per section. R. B. R.

1410. *Large Generators.* **A. Rothert.** (Elektrotechn. Zeitschr. 22. pp. 191–194, Feb. 28, 1901.)—The author draws an interesting comparison between some large generators designed by Parshall and a set of machines designed by himself. In finding the dimensions of his machines, Parshall commences by assuming a certain efficiency; the waste power is then suitably apportioned to the various sources of loss, such as the heat loss in the field coils, that in the armature, the iron loss, &c. From these the necessary cooling surfaces are determined. The author, on the other hand, uses a coefficient which gives the length of armature core for any assumed diameter. He next chooses the number of poles, which is regarded as dependent mainly on the angular velocity, and fixes the dimensions of the armature so that the polar surface becomes approximately a square, the steel field-core being cylindrical. The machines under consideration range from 125 to 650 kilowatts as regards output, and from 150 to 80 revs. per minute as regards speed.

Parshall gives 2·25 per cent. as the average value of the loss due to armature resistance. In the author's machines this quantity is 2·7 per cent. for the larger sizes, and reaches a value of over 4 per cent. in the 125 k.w. size (125 revs. per min.). The current-density in the armature conductors amounts to 2·3 amperes per sq. mm. in Parshall's, and to between 2·68 and 2·95 amperes per sq. mm. in the author's machines. The apparent maximum induction in the teeth is in Parshall's machines, 21,500, and in the author's, 23,500. In the latter machines there are 2 or 3 commutator segments per tooth, and the slots are from 10 to 17·5 mm. wide (in the case of large machines 13 to 14 mm. is an average value), and from 35 to 45 mm. deep. The induction in the armature core is from 11,500 to 12,000 in the author's machines. The peripheral velocity is about 12 metres per sec. in Parshall's machines, and varies from 8 to 10·5 in the author's. Parshall uses 10 poles

where the author uses 14. The leakage coefficient is given by Parshall as 1·15 on open circuit and 1·18 at full load; the author's figures being 1·14 and 1·23. The polar arc in Parshall's machines is 80 per cent., and in the author's 72 per cent., of the pole-pitch. The field-core induction in Parshall's machines is 15,800, in the author's somewhat higher. The paper concludes with a detailed account of a generator exhibited by Siemens and Halske at the Paris Exposition. [See also Abstract No. 243 (1901).] A. H.

1411. *Starting Device for Three-phase Railway Motors.* **A. Krebs.** (Elekt. Runds. 18. pp. 85–86, Feb. 1, 1901.)—This device, proposed by the author and illustrated in the accompanying sketch, is intended to reduce the heavy starting currents taken by 3-phase motors, and to provide a means of controlling the speed of, and braking, such motors. The leading idea is to vary the frequency of the currents supplied to the motor. The device is specially intended for high-speed railway service. High-tension three-phase currents are, by means of three trolleys, tapped from overhead conductors and led into the primary winding of a transformer placed on the locomotive. This transformer has a ring core, and its secondary is arranged like an ordinary Gramme winding with a commutator, against which press three brushes, b_1, b_2, and b_3,



spaced 120° apart. The commutator is fixed, but its brushes are capable of rotation, being fixed to a brush disc driven by a small auxiliary motor AM. The brushes are connected to three slip-rings, R_1, R_2, and R_3. From these latter connections are carried, through the brushes B_1, B_2, B_3, to the main motors, with, if necessary, the interposition of small starting resistances. If the brushes are rotated synchronously, then it is evident that the currents supplied to the motors are of zero frequency. As the speed of rotation of the brushes is gradually decreased, the frequency of the motor currents increases, until when the brushes are brought to rest the frequency equals that of the primary currents. By this means very rapid acceleration with currents not exceeding the normal ones may be obtained. Further, a braking effect is easily produced by setting the brushes in rotation, and thereby causing the motors to act as generators. A. H.

1412. *Friction and Hysteresis Losses in Induction Motors.* **J. Hissink.** (Elektrotechn. Zeitschr. 22. pp. 226–227; Discussion, pp. 227–228, March 7, 1901. Paper read before the Elektrotechn. Verein, Dec. 18, 1900.)—It has

frequently been observed that whereas in the case of transformers the calculated hysteresis loss corresponds closely to that determined experimentally, the experimental determination in the case of induction motors constructed of the same kind of iron gives results which are from 2 to 2½ times those obtained by calculation. The method commonly employed for separating the losses consists in measuring the total power taken by the motor when running light at different p.d.s. It is then assumed that, since the speed of the motor at the various p.d.s is practically the same, the friction loss remains constant. By producing the curve connecting power with p.d. backwards, this supposed constant frictional loss may be obtained. The author points out that this reasoning is only applicable to an ideal motor whose rotor is absolutely concentric with the bore of the stator. The air-gap being extremely small, the slightest amount of eccentricity will result in (1) a strong magnetic pull which will increase the friction loss; and (2) an irregular distribution of the magnetic flux, which will increase the hysteresis loss. These two effects are sufficient to account for the great increase in the observed loss as compared with the calculated one. The author describes experiments which confirm this view. In one case, the air-gap of a motor with a squirrel-cage rotor was gradually increased, and—as might have been expected—it was found that the hysteresis loss decreased rapidly at first, then more and more slowly. In order to separate the stator hysteresis loss from the friction loss, the author measured the power taken by the stator when the rotor was (*a*) running light; and (*b*) driven synchronously by an auxiliary synchronous motor coupled to it.

Discussion.—**Görges** stated that the increase in the hysteresis loss had frequently been observed in the works of Siemens and Halske. He drew attention to the fact that with a different number of slots in the stator and rotor cores the induction in the teeth underwent extremely rapid fluctuations, and this would partly account for the increase in the hysteresis loss. A. H.

1413. *New Form of Synchronous Motor.* **H. Grob.** (Elektrotechn. Zeitschr. 22. pp. 211–212, March 7, 1901.)—The author proposes to couple the stator and rotor circuits of an ordinary induction motor in series with each other, and then across the supply mains. The polyphase currents in the stator and rotor windings will give rise to two rotating fields. Let the connections be so arranged that the fields rotate in opposite directions. Further, let the rotor be run up to a speed double that of its field, but having the opposite direction. The result is to impart to both fields the same velocity *in space*, and hence to enable the stator field to exert a torque on the rotor should the latter be displaced from the position of equilibrium. The author finds that the behaviour of such a motor may be graphically represented by a diagram which closely resembles Heyland's diagram for an induction motor. Such a motor is obviously not self-starting, and must be run up to the speed of synchronism. The author compares the behaviour of an induction motor as ordinarily used with that of the same motor when its circuits are joined in series with each other as explained, the same values of the iron and copper losses being assumed in each case. This will require a p.d. of supply for the synchronous motor equal to double that of the non-synchronous one. The speed and power of the synchronous motor will (as already explained) be double those of the other; its no-load current will be half, its maximum torque double, its power-factor higher than, and its efficiency about equal to, those of the non-synchronous motor. Assuming next that the motors run at the same speed (in order to obtain this, it will be necessary to re-wind the

synchronous motor so as to give it double the number of poles), the author finds that the supply p.d. and no-load current will be the same, that the maximum torque of the synchronous motor will be double, and its power-factor higher than those of the non-synchronous motor.[1] A. H.

1414. *Transformer Design.* **W. B. Woodhouse.** (Electrician, 46. pp. 625–627, Feb. 15 ; and 687-689, March 1, 1901.) A practical discussion is given of the design of transformers. The relative merits of the core and shell types are stated, and formulæ are given for the dimensions of the stampings. The importance of considering the rise of temperature in large transformers is pointed out. If we have two similar transformers, and the linear dimensions of the one are n times those of the other, and if we keep the flux density the same in each, and if the same proportion of the space be taken up by the windings, then while the output increases as n^3 the cooling surface only increases as n^2. The following rules are given. For an air-cooled transformer with natural draught the rise of temperature in degrees Fahrenheit is $300\,m^{\frac{2}{3}}$ where m is the ratio of the watts wasted to the area of the cooling surface in square inches. For an air-cooled transformer the rise of temperature is $225\,m^{\frac{2}{3}}$. Kapp's empirical formulæ to predetermine the pressure drop in the secondary are given. The author states that much labour will be saved in designing if certain curves, which he describes, showing temperature rise, watts wasted in hysteresis, and connecting linear dimensions with cooling surface, be plotted out. He concludes by working out completely the design of a ten kilowatt core transformer. A. R.

REFERENCES.

1415. *Comparison of Surface-Wound and Slot-Wound Armatures.* **P. M. Heldt.** (Amer. Electn. 13. pp. 106–107, March, 1901.)—The author gives details of two dynamos of about the same weight, one with a smooth core armature giving $7\frac{1}{2}$ kw. at 1,200 revs., the other with slotted armature giving $12\frac{1}{2}$ kw. at 940 revs. The bore of the machine with smooth core was $10\frac{13}{16}$ inches, and of the other $12\frac{3}{8}$ inches. R. B. R.

1416. *Asynchronous Generators.* **O. M. Corbino.** (N. Cimento, 1. pp. 178–182, March, 1901.)—The author treats analytically and geometrically the theory of an asynchronous rotary field motor, when acting as a generator. G. H. B.

1417. *Pressure Drop in Three-Phase Generators.* **F. Niethammer.** (Elektrotechn. Zeitschr. 22. pp. 255–256, March 21, 1901.)—The author develops a graphical method of predetermining the regulation of a three-phase generator. The method is based on a consideration of the effective ampere-turns acting on the armature, these ampere-turns being obtained by suitably compounding the field and armature ampere-turns, due account being taken of magnetic leakage. The details of the method do not admit of a useful abstract. A. H.

1418. *Compounding of Alternators.* **Strymeersch.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 19–46, March 21, 1901.)—This is simply a description of the known methods due to Hutin and Leblanc, Boucherot, and Blondel. W. G. R.

1419. *Distribution of Magnetic Flux in Induction Motors.* **J. B. Krantz.** (Elektrotechn. Zeitschr. 22. pp. 274–275, March 28, 1901.)—A mathematical paper dealing with this problem. A. H.

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[1] In a foot-note, the author states that since his paper was written the arrangement described has been patented by another inventor.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1420. *Economical Current Density for Small Conductors.* **J. Whitcher.** (Elect. Rev. 48. pp. 361–362, March 1, and 396–397, March 8, 1901.) The writer points out the absurdity of insisting on a 2 or 3 per cent. limit for the voltage loss in long runs, and by applying the Kelvin law finds that the economical current density should be 700 or 800 amperes per square inch, on the average, for general wiring work. The cost per unit is taken at 4d., and interest and depreciation at 7½ per cent. W. H. E.

1421. *Transformer Regulation on Three-wire and Three-phase Systems.* **M. v. Dolivo-Dobrowolsky.** (Elektrotechn. Zeitschr. 22. pp. 265–266, March 21, 1901. Paper read before the Elektrotechn. Verein, Feb. 26, 1901.)—When a transformer with two legs is connected to a three-wire circuit, one leg-winding being on each side, a difference in the load on the two sides produces very large variations in the pressure; this is due to the primary current required on the loaded side being unable to pass through the less loaded side, when the two primary coils are, as is usual, connected in series. When the two windings are on one leg only, or both on each leg, the regulation is better, but not perfect. The method adopted by the author to obviate this difficulty, is to connect the two primary windings, corresponding to the two secondaries in parallel. The regulation, then, is equally good as with two-wire circuits, even with great variations of load on the two sides. The same object is attained in three-phase circuits, by connecting the primary in mesh and the secondary in star. Such transformers with mixed connections can be connected to work in parallel, but two transformers, one with mixed and the other with similar connections, will not work in parallel. G. H. B.

1422. *Economy of Copper in Transmission Lines.* **M. Latour.** (Écl. Électr. 26. pp. 279–281, Feb. 23, 1901.)—The author points out, from considerations partly mathematical, that the use of accumulators at the distant end of a line may conduce to economy in the cost of a transmission line, in cases where the power is transmitted over comparatively short distances. This is due to the possibility of sending along the transmission line a constant current, which is equivalent to the mean amount of current required throughout the day, or, in other words, to the possibility of maintaining a constant load on the running machinery. He shows that if, under the usual conditions, full load is maintained on the line during eight hours of the day, and there is no load during the remaining sixteen hours, the loss in the transmission line is three times as great as it would be, if with the use of accumulators it were possible to maintain a steady load on the line, equal to the mean load required. It is pointed out that this requires to be somewhat corrected to allow for the fact that the efficiency of the batteries is not 100 per cent.; but even allowing for this, the line loss would be much smaller in the one case than in the other. The matter may be put in another way: it is possible to have much less copper in the line in the one case than in the other, and yet have equal daily loss in the line; and, consequently from the point of view of the author,

the use of accumulators may be said to conduce to economy in the cost of copper. No estimate is, however, made of the cost of plant under the two conditions, though it is pointed out that the use of accumulators dispenses with the cost of transformers at the distributing station. W. H. S.

1423. *Plant for Electrical Distribution.* **C. F. Scott.** (Frank. Inst., Journ. 151. pp. 282–308, April, 1901.)—This paper begins with a comparison between the advantages of alternating and direct current for central station work, the author advocating the use of the former for long-distance transmission. A general description follows of the construction of a Westinghouse flywheel alternator, the advantage of a large number of slots in the armature being dwelt on, as tending to reduce the self-induction of the machine. The problem of parallel running is considered, and the analogy between two electrically-coupled generators and two gear wheels transmitting power to a shaft is developed at length. Engines with a considerable speed variation between no load and full are better for parallel working than those which regulate very closely; too great sensitiveness in the governor sets up a tendency to hunt, which can be counteracted by the use of a dash pot. The construction and uses of rotary converters are described; an effective remedy for the oscillations sometimes set up in the armature of a rotary by variation of speed of the generator is a copper shield round the field poles. Rotaries and synchronous motors, if running badly, may influence adversely the behaviour of similar machines on the same circuit; induction motors, on the other hand, facilitate the operation of rotaries and also the parallel running of the generators. A description follows of the Westinghouse type "C" induction motor, and such motors generally are compared with direct-current motors from the points of view of efficiency, simplicity of construction and working, capacity for overload, reliability, &c.—the balance of advantage being, in the author's opinion, in favour of the former.

In conclusion, the author expresses the opinion that the alternator is the form of generator which will be used in the central station of the future, and that the inherent possibilities of the gas engine, and its greater efficiency as compared with steam, will be developed to an extent which will effect an industrial revolution. The article is illustrated by photo blocks. B. P. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1424. *Trafford Park Power Station.* (Elect. Engin. 27, pp. 366–371, March 15, and 402–405, March 22, 1901.)—Trafford Park, near Manchester, is bounded on two sides by the Manchester Ship Canal and on the other two by the Bridgewater Canal. Numerous factories are established on the estate, and the Trafford Park Power Station has been laid down to supply current for power and lighting purposes, and also Mond gas for heating, to consumers on the estate. Negotiations are in hand for supplying three local authorities whose districts adjoin Trafford Park.

The *system* is continuous current three-wire at 500 volts between the outers; for distant consumers a three-phase high-tension supply is contemplated.

Gas plant has been put down on the Mond system for supplying gaseous fuel to the boilers, with recovery of by-products. The fuel used is slack at 7s. per ton; including the labour of handling and removing the ashes, the cost is 8s. 6d. One ton of sulphate of ammonia, worth £11, can be obtained from 23 tons of coal; the by-product, therefore, per ton of coal, is worth 3s. more

than the original cost of the coal. The steam for the producers will be obtained from the steam engine exhausts. The gas, as it leaves the producers, is passed through large regenerator pipes to the washers, from which, after extraction of the ammonium sulphate, it passes to the mains supplying the boilers and the consumers. The boiler furnaces are arranged to burn either coal or gas ; the gas is burnt below the level of the fire-bars, in a chamber divided by a zig-zag partition of firebrick. Air is admitted at one side of the partition and gas at the other, combustion taking place above the partition. The products of combustion pass through interstices in a crown arch of fire-brick ; this arch, becoming very hot, ensures complete combustion. A small furnace is used for heating the Schmidt superheaters, which will give 300° F. of superheat. The makers guarantee a saving of 7 lbs. of steam per i.h.p. by the use of the superheater.

The *boiler-house* contains four Babcock and Wilcox boilers, and one tubular boiler of a new type by Tinkers.

The *engine-room* contains four Raworth engines coupled direct to Mather and Platt multi-polar direct-current dynamos ; two 500 h.p. engines are mounted on one shaft and drive one dynamo, giving 1,200 amperes at 500–550 volts, running at 200 r.p.m. The exhaust steam, when not required for the producer blast, is condensed in injector condensers of the Ledward type. Centrifugal pumps driven by Royce motors draw the cooling water from the Bridgewater canal. Two balancing sets by the Electric Construction Corporation are capable of dealing with 50 amperes each.

The *feeders* are three in number, supplied and laid by Glover and Co. ; they consist each of three separate cables insulated with paper and lead covered. The outers have a section of 0·5 sq. in., and the middle wire a section of 0·125 sq. in. They are laid in Doulton conduits.

The *system of charging* is on the maximum demand system, being 1½d. per unit up to an average use of the maximum demand for 1,200 hours per annum, and ½d. per unit for further energy. On this basis an ordinary factory would obtain energy for less than 1d. per unit. For lighting the charge is 4d. per unit for the first 400 hours per annum, and 1½d. per unit for energy above this quantity. A load-curve for Feb. 22, 1901, shows a variation in current of from 165 to 370 amperes. For extensions the engineers are contemplating the use of large gas engines coupled directly to dynamos.

The paper is illustrated by a map, eleven scale drawings, and several photographic views. G. H. B.

1425. *Nottingham Corporation Electricity Works.* (Elect. Rev. 48. pp. 63–69, Jan. 11, 1901.)—The present plant has a capacity of 5,600 kw., and an entirely new station is about to be erected with a capacity of 10,000 kw. Owing to a high load factor (600 h.p. in motors), the price is very low—5d. and 2d. on the Wright system. In the new station there will be 9 Willans-Siemens sets, most of which are now running. The engines are of the standard "3S" type, compound non-condensing, running at 300 r.p.m. The dynamos have eight poles, with circular cast steel magnets, the cores being cast with the frame and the polar extensions bolted to them. The edges of the pole-tips are double wedge-shaped, so that the polar arc is greater at the middle of the armature than at the ends. The toothed armature weighs 9 tons, and no flywheel is required. The shunt field rheostat is mounted at the side of the machine, and consists of two switches, so as to secure fine adjustment with few steps. The main terminals are below the floor level, and are approached by a stairway. The cables are Callenders in bitumen casing or

armoured, and laid direct in the ground. The connections amount to 127,000 8-c.p. lamps and 600 h.p. in motors.

The traction sets resemble the lighting sets and have no flywheels, but the engines have automatic variable cut-off governors as well as throttle governors, and the dynamos are compound wound. The new boiler-house will contain 14 dryback boilers by Edwin Danks, 16 feet long by 8 ft. 6 in. diameter, with two furnaces 3 feet in diameter, and 86 3-inch return tubes. There are two Berryman exhaust steam feed-water heaters, each 21 ft. 6 in. high by 4 ft. 3 in. diameter. Condensed water from these and from the drains is collected in two tanks, which are also connected with the town mains. Four Weir feed-pumps draw from these tanks. Feed piping is in duplicate throughout. Each boiler is fitted with an anti-priming steam chamber, from the top of which is taken the connection to the steam main. Steam pipe joints are made with Taylor's corrugated brass rings. There are 12 cars now in use. The overhead trolley wire is flexibly supported in "bowstring" manner. E. H. C.-H.

1426. *Nottingham City Tramways.* (Tram. Rly. World, 10. pp. 51–59, Feb. 1901.)—Since 1877, when the tramways were opened, Nottingham has more than doubled ; but no addition has been made to the original ten miles of line, in spite of the heavy traffic. During 1899 the population was carried 34 times, the earnings being 14·01d. per car-mile. The district is hilly, but the steepest gradient is 1 in 14. The rails are 7-inch girder type, 107 lbs. per yard, in 60 feet lengths. With proper appliances no difficulty has been found with the 60 feet lengths. Joints are made with fish-plates 2 ft. 7in. long, with eight 1-inch bolts, the pair of plates weighing 77½ lbs. Secured to the bottom flange of the rail by four ⅞-inch bolts is a sole plate 2 ft. 6 in. long by 8 inches wide and ¾ inches thick. Duplicate crown bonds are used between the fish-plates and the rails, and Chicago cross bonds every 40 yards. Points and crossings are curved, not straight. Six inches of 6 : 1 Portland cement concrete are laid under the track throughout. There are 57 double-deck cars of the new Liverpool pattern, holding 22 inside and 34 outside, mounted on "21 E" Brill trucks with 6 feet wheel base and Miller's wheels. Each motor gives 30 h.p. at 8 m.p.h. Spencer's patent slipper brake is used in addition to hand and electric brakes, the latter acting by short-circuiting each armature on itself. Feeder cables are Callender's vulcanised bitumen laid in vitrified stoneware ducts. Feeders are so arranged that if the line feeder breaks down, the switches can be reversed so that the return feeder takes its place. The trolley wire has a diameter 0·409 inch. A new power station, fairly central, is under construction. Its boiler-house, 240 feet by 53 feet, will contain 16 Lancashire boilers, 30 feet by 8 feet, for 160 lbs. per sq. in., fired by Vicar's mechanical stokers. Pits are provided for 300 tons of coal, which will be dealt with by conveyors and elevators. The engine house will be 206 feet by 40 feet, and will hold twelve 700 h.p. Willans-Siemens sets. The chimney stack will be 220 feet high, by 15 feet inside diameter at base. E. H. C.-H.

1427. *Lowestoft Electricity Works.* (Elect. Engin. 27. pp. 294–296, and Supplement pp. 1–8, March 1, 1901.)—The four boilers are by Babcock-Wilcox, and the bottom row of tubes is so arranged as to form a double-combustion chamber, for burning bituminous coal. The working pressure is 200 lbs. per square inch. The engines are of the Musgrave enclosed type, with piston valves, the high-pressure valve being controlled by an automatic governor. The capacity of the plant will be 475 kw. at 2 × 230

volts ; there is also a battery of Chloride cells giving 100 amperes for four hours, or 270 for one hour. There are four feeders, two being triple concentric, armoured and laid direct in the ground. All the mains were supplied by Callender, and have vulcanised bitumen insulation. The distributors are laid in wooden troughs filled with refined bitumen.

With a view to future extensions, three spare 3-inch stoneware pipes were laid in the same trench as the present feeders.

For street lighting there are 68 five-ampere enclosed Crompton arc lamps, run four in series on 7/18 cable across the outer distributors, and incandescent lamps on the arc posts. An automatic cut-out is provided in each lamp so as to substitute a resistance in case of failure in the arc. W. H. E.

1428. *Isle of Thanet Tramways.* (Electrician, 46. pp. 968–975, April 19, 1901.)—These tramways have been constructed to connect Margate and Ramsgate, and include at present about eleven miles of track. Electric lighting will also be undertaken by the Tramway Company, and Provisional Orders have been obtained for several places on the line of route. The power-house is situated about the middle of the line, nearly midway between Margate and Ramsgate. It contains four Babcock boilers, each with a heating surface of 3,140 square feet, which supply steam to a single main 10 inches in diameter. Two vertical feed pumps are used, each having a capacity of 5,000 gallons an hour. Water for feed and condensing purposes is obtained from a well 150 feet deep, the feed water being softened by the Desrumaux apparatus, and subsequently heated by an economiser of 240 tubes. The engine-room at present contains two 200-kw. continuous-current traction generators, and two 300-kw. three-phase generators, giving their output at 2,500 volts. The continuous-current sets are driven by Allis engines at 135 r.p.m., the engines having flywheels 14 feet in diameter, weighing over 10 tons. The three-phase sets are direct coupled to Belliss engines, running at 300 r.p.m. There are three Wheeler condensers, each having a cooling surface of 1,570 square feet, and these are worked in conjunction with a Barnard-Wheeler cooling tower. The travelling crane in the engine-room has a capacity of 15 tons, and covers a span of 49 feet. The car-sheds contain eight tracks with continuous inspection chambers under all the tracks, and can hold about 40 cars. The cars are partly on single trucks and partly on bogies, and all are double decked ; they seat 50 and 62 passengers respectively. The steepest gradient on the line is 1 in 13, and the sharpest curve has a radius of 38 feet ; the gauge is 3 ft. 6 in. The line is mainly composed of double track, which is to a large extent interlacing. The rails weigh 83 lbs. per yard. On straight runs the poles are about 120 feet apart. The substations at Ramsgate and Margate are to contain two and four 100-kw. rotary converters respectively. The article contains drawings showing the general plan and cross-section of the power-house, the construction of single and interlacing track, the connections on the substation switchboard, &c. W. H. S.

1429. *Huddersfield Electric Tramways.* (Elect. Engin. 27. pp. 222–233, Feb. 15, 1901.)—The Corporation own 52 miles of single track, varying in altitude between 200 and 800 feet above sea-level. The equivalent of nearly 16 miles of single track has now been equipped electrically. The power-station is central, on the River Colne, and all current is supplied direct at 500 volts. The boiler-house is 107 feet long, 59 feet wide, and 23 feet high, constructed for eight Lancashire boilers. Outside the building a coal hopper

and elevator are arranged in conjunction with Vicars' mechanical stokers. The engine-house is 130 feet long, 42½ feet wide, and 35 feet high. Car-sheds provide for 25 cars with inspection pits between each line of rails. Recent extensions of the steam tramways were made with 98-lb. girder rails having a groove only ⅞ inch deep; it was found that the tread wore away so quickly that the wheels ran on their flanges in less than 15 years. The new rails are of the same weight, but with grove $1\frac{1}{16}$ inch deep, and have fish plates 2 ft. 6 in. long. Each joint is double bonded with 0000 "Columbia" bonds, hydraulically pressed into drilled holes: cross bonds are placed every 120 feet.

The power-house now contains three Lancashire boilers, 30 ft. × 8 ft. 6 in. diameter, constructed for 180 lbs. working pressure. Their outside shell is of $\frac{15}{16}$ inch plate, the flues 3 ft. 5 in. diameter in 18 rings with welded longitudinal seams and flanged ends. The Vicars stokers have special clinkering nozzles to allow the clinker to be broken while the furnaces are working. Coal from carts is tipped into an elevator pit, whence steel buckets on an endless chain transfer it to a conveyor, along which it is moved by a large screw to the furnace hopper, whence the supply to the furnaces is automatically regulated. For driving this elevator and conveyor, and also the economiser scrapers, a 10-b.h.p. motor is provided, driven from the bus-bars or from the station lighting set.

The boiler mountings and all valves are Hopkinson's, and include a new form of accessible check-feed valve arranged so that an upper part of the valve can be closed, allowing the check valve and seat to be removed while the boiler is in use. The steam and water piping is in duplicate, the former being of mild steel, the main branches lapwelded with screwed flanges, into which the pipes are expanded. A Musgrave superheater with 38 tubes is placed at the back of each boiler to ensure dry steam: a by-pass pipe can be put round the superheater if required. The main engines are Musgrave's vertical inverted cylinder compound condensing type, with automatic cut-off gear. The cylinders are 17½ inches and 35 inches with 35-inch stroke. The air-pump is 24 inches diameter, 14-inch stroke, the pump bucket having a series of small indiarubber valves, also delivery grid with rubber valves. The arrangement works well and greatly reduces shock on closing. The jet condenser is supplied from the River Colne. The cast-iron engine flywheel is 18 feet diameter, and has 10 tons in rim alone. Forced lubrication is supplied to all parts by two ram pumps, each capable of doing the whole lubrication if necessary. Each of the two engines is rated at 520 i.h.p. at 90 r.p.m., with 160 lbs. steam, and will work up to 650 i.h.p. The generators are of the compound-wound multipolar type with inwardly projecting poles and slotted armature keyed on to the engine shaft: each gives 375 k.w. at 500 to 550 volts. A 25-k.w. Reavell-B.T.H. set is provided for station lighting, &c. The engine-house is spanned by a 25-ton crane. The switchboard is of B.T.H. standard panel design, as also is the equipment of the overhead line and of the cars. The trolley wire is 00 B. & S. hard-drawn copper on span wires, side or double brackets, with poles 120 feet apart. Both line and rail are fed at three separate points, where switches are arranged so that the rail-feeder can be used for line feeding if the line feeder breaks down. The return conductors are not earthed at the station, but at central points on the routes, where recording ammeters are placed. The extreme drop is 3½ volts in the town and 5 volts in the outskirts. The cars, by Milnes, have bodies 18 ft. 6 in. long, and carry 24 inside and 33 outside. They are mounted on Brill maximum traction trucks, and each carries two G.E.-58 motors rated at 27 b.h.p. each. The controllers are of the B.-18 type with electric brakes, using the motors as

generators on resistances. The average period of service of the whole of the drivers, conductors, &c., on the tramways is 10¾ years, and the yearly outlay in compensation for accidents during the last five years with steam traction averaged £165, equal to 7d. per car per day, whereas insurance companies ask premiums equivalent to 10½d. per car per day. E. H. C.-H.

1430. *Darwen Refuse Destructor and Electricty Works.* (Tram. Rly. World, 10. pp. 60–71, Feb., 1901.)—This town adjoins Blackburn, and part of the tramway lines are used by the cars of both Corporations. In Darwen the greater part of the steam required for traction and lighting is generated by two Meldrum destructors. Each consists of furnace, combustion and dust-deposit chamber, and regenerator, with a Lancashire boiler measuring 30 feet by 8 feet. The furnace extends alongside the boiler for a distance of 19 feet, with a width of 5 ft. 6 in., and has four doors, each with its own ashpit. Each ashpit is fitted with Meldrum forced draught apparatus, consisting of steam blowers which draw air through the regenerator. The flames and gases pass into a combustion chamber 17 ft. 6 in. long, 4 feet wide, and 10 ft. 6 in. high, placed at right angles to the furnace and extending across the end of the boiler. The hot gases pass through, along, and then under the boiler, as usual, and afterwards traverse the regenerator in a set of 3-inch iron pipes, thus heating up the air around them, which is used for the furnace draught. The chimney is 240 feet in height, but a temporary iron chimney, 80 feet high and 3 feet in diameter, was used for seven months, and no complaints were received from residents in the vicinity, the escaping smoke being scarcely visible. A 48 hours' test gave the following results :—

Total quantity of refuse (consisting almost entirely of unscreened ashpit refuse)	63·88 tons.
Average moisture	38 per cent.
Weight of clinker remaining (19½ tons)	30·6 per cent.
Water evaporated (from and at 212°) per lb. of refuse	1·55 lbs.
Average steam pressure per square inch	183 lbs.
Average temperature of combustion chamber	1,633° F.
„ „ „ gases after leaving boiler	703° F.
„ „ „ gases after leaving regenerator	585° F.
„ „ „ feed air from regenerator	328° F.

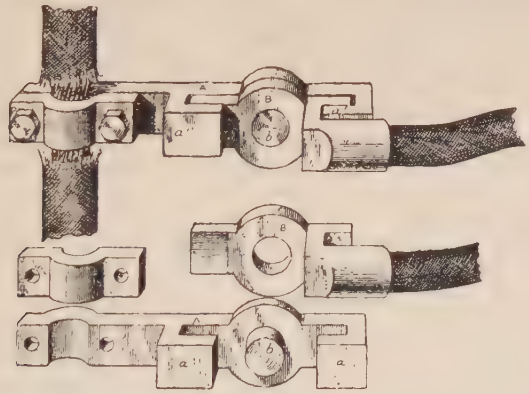
The quantity of refuse dealt with daily is from 32 to 38 tons, though the plant can consume 70 tons daily. The population numbers 40,000, and the destructors generate steam for about 900,000 kw.-hours per annum. Two coal-fired boilers are required in addition. The average evaporation has been 1·5 lbs. of water (at 212° F.) per lb. of refuse, giving a value for the refuse of about 3s. per ton, while the cost of destruction is about 2s. per ton. The power is sold to the Electricity Department by the Sanitary Committee at the rate of 0·6d. per net electrical unit. The electrical plant is described in the paper and is on ordinary lines. W. H. E.

1431. *Recent Tramway Work in San Francisco.* **S. L. Foster.** (Street Rly. Journ. 17. pp. 187–193, March, 1901.)—Several old cable lines of the Market Street Railway Company have recently been converted to electric traction. The old cable tube was left, the slot rails removed, and the tube and sheave pits filled up. Instead of fish-plates and bonds, Falk cast-welded joints were used. Careful tests on 2,000 joints showed that in 80 per cent. of the sound cast-welded joints the conductivity was not less than that of an

equal length of jointless rail. On the latest work, after eleven months' use, only 0·24 per cent. of the cast-joints were broken. The rails are cross-bonded every 150 feet as a safeguard against broken welds. It is found best to omit every fourth joint, leaving the welding of the omitted joints till some cold night. In this way the cast iron is practically always under compression, and is therefore less liable to crack with a sharp blow than if under tension. One gradient of 17½ per cent. is 200 feet long, but the electric cars are operated up and down without mechanical assistance. On two 25 per cent. gradients the ascending and descending cars are coupled by cable while on the grade. A new standard car has been adopted, 40 feet long, equipped with four G.E. 25-h.p. motors. This takes twice the kw.-hours per car-mile that the 28-feet single-truck cars do, but the extra cost of power is more than offset by saving on wages per passenger carried. Single trolley poles are used, even on the 40-feet cars. Special track brakes are used, consisting of wooden replaceable shoes forced down on to the rails between the wheels of each truck. The brake handle is an upright lever, and acts on the shoes through toggle joints. It is claimed that this form of lever is responsible for the compensation claim being only 1 per cent. of the gross earning in San Francisco as compared with from 3 to 7½ per cent. in the Eastern States. With the rotary brake handle valuable time is always wasted in taking up slack. Four sand-boxes are used, one over each rail at each end of the car. A special car for engineers' use is equipped with two G.E.-1,000 motors, and will easily haul 8 tons of dead load over the heavy grades. E. H. C.-H.

1432. *Albany and Hudson Third-Rail Road.* (Street Rly. Journ. 17. pp. 101–112, Feb., 1901.)—This is the longest third-rail electric line in the world, being 37 miles in length. It is supplied with power from the Stuyvesant Falls, which are at a point on the line about 10 miles from one end. There is also an auxiliary steam plant of 1,750 h.p. The electric generators include three 750-kw. three-phase generators, working at 25 cycles and 12,000 volts; also two 200-kw. 600-volt direct-current generators for supplying the section of the line nearest the power-house. The 12,000-volt current is taken by overhead wires to three substations, and is there reduced by transformers to 380 volts, and then supplied to rotaries which convert it into direct current at 600 volts. The power-house also contains some single-phase generators, which are used for lighting purposes; these work at 60 cycles per second. The frequency of the three-phase machines is too low for lighting purposes, but was considered the most suitable for use in connection with rotary converters. Hence two different frequencies were used. The track is laid with 80-lb. T-rail. The third rail is raised six inches above the track, and is supported every ten feet by wooden blocks. Over these blocks are fitted malleable cast-iron caps or chairs, on which the rail rests. The third rail contains less carbon than the other two, with a view to reducing its electrical resistance. Contact with the rail is made by shoes, of which each car carries four, two on each side. These shoes are 31 feet apart, and are arranged in this way in order to meet the interruption of the third rail at farm and road crossings. The shoes are let up or down, swivel fashion, according as current is required or not. The trains are capable of travelling at 50 miles an hour. The article contains several drawings, showing the designs of the station and substations, and the connections on the various switchboards. A drawing showing the construction of the contact-shoe and the lifting mechanism is given in an article in the Electrical World and Engineer of December 8, 1900, and a short description of the line appeared in the Electrician of December 28, 1900. W. H. S.

1433. *Hoboken Power Station.* (Elect. World and Engineer, 37. pp. 467–470, March 23, 1901.)—The description of the station at Hoboken, of the United Electric Company of New Jersey, is of some interest as an example of changing-over. The whole of the belted plant has been replaced by direct-connected units of the most modern practice, and the e.m.f. has been raised from 1,040 to 2,400 volts without shutting down any circuit. The chief plant consists of General Electric railway generators of 850 kw. at 90 r.p.m., and Stanley two-phase alternators giving 2,400 volts at 60 ∿ and capable of a load of 1,050 kw. for three hours. For arc lighting there are four 150 kw. 2,400-volt synchronous Stanley motors, each direct connected with two 125-light 2,000 c.p. Brush machines. The connection between the motors and dynamos is made by means of a flexible coupling, consisting of a four-arm spider on each motor and dynamo shaft, connection between them being made by leather links. Each motor is brought up to synchronism by a 15-h.p. Sprague motor. The connection between the synchronous motor and the starting motor is made by means of a raw-hide intermediate pinion



secured to a lever so that it can easily be thrown in or out of gear. Descriptions are given of the several switchboards. One of the panels of the alternating current board is employed for supplying current to two 100-kw. step-up transformers connected on the Scott system for supplying the Jersey City station with 6,600 volt three-phase currents; at the receiving end the current is stepped down to 2,400 volts two-phase.

A "jumper" device designed by H. D. King is described. By its means connection may be made in a few seconds between one switchboard panel and another in case of accident. It consists of three castings. The main part A is, as shown, intended to be clamped to a cable, and is provided with the lugs *a* and a^1. The inner surfaces are bevelled, and when the portion B is slipped over the projecting stud *b* and given a quarter turn, the prepared surfaces are brought together and a good contact ensured. The B end of the "jumper" cable is then connected to any desired panel in a similar manner. W. W. H. G.

1434. *Transmission at the Cochiti Gold Mines at* 20,000 *volts.* **F. W. Hart.** (Elect. World and Engineer, 37. pp. 345–349, March 2, 1901.)—Owing to the impracticability of getting sufficient fuel at the Cochiti Gold Mines, near Bland, in Mexico, electrical plant was put down at coal mines 32 miles distant. The total cost of supplying power with the old steam plant, using

coal-wood as fuel, and hoisting and milling 200 tons per 24 hours, was $218 per diem. The cost of doing the work now with electric power generated and transmitted 32 miles is $52.75 per diem for hoisting and treating 300 tons. These figures do not include interest or depreciation on either plant. Feed-water at the coal mines is obtained from artesian wells, and contains 38 per cent. of incrustating solids, but boilers are carefully inspected and cleaned every eight days, and give no trouble. The power-house will contain two General Electric three-phase, revolving-field type, 605-volt, 60-cycle generators, direct connected to Allis-Corliss engines, running at 90 r.p.m., having fly-wheels 20 feet in diameter, weighing 70,000 lbs. Only one of these units is installed at present. The commercial efficiencies of the generators, not including friction losses, are 93 per cent. at full load, non-inductive; 92 per cent. at three-quarter load, non-inductive; and 89 per cent. at half load, non-inductive. There are two 125-volt compound-wound exciters, one steam-driven and the other motor-driven. A third will be added. Three step-up transformers of 200 kw. each, of the vertical air-blast type, transform a voltage of 605 to 20,000, and have a full-load efficiency of 97 per cent. The switch-board has two sets of bus-bars, double-throw oil switches, expulsion fuse blocks, &c. The 20,000 volt switches are of the knife-blade type, and they, as well as the expulsion fuse blocks, are provided with large marble barrier plates. The boiler equipment consists of two batteries, each consisting of three 175-h.p. return tubular boilers, built for 125 lbs. working pressure. This type of boiler was used on account of the bad feed-water. Coal is fed from a weighing hopper direct into a Jeffrey conveyor, which delivers it into steel coal bins above the boilers, the bins having a capacity of 100 tons. Thence it is drawn through spouts at convenient points in front of each boiler. A coal crusher is provided, so that, in case the supply of slack is not sufficient for the demands of the plant, "mine run" can be handled. An ash conveyor delivers the ashes into a storage hopper, from which they are drawn into a steel ash-car. With this coal and ash arrangement, one man per shift easily does the firing. The coal crusher and ash and coal conveyor are each driven by a 10-h.p. induction motor. The pole line is designed to eventually carry two circuits of No. 4 wire, the three wires of each circuit being placed at the points of an equilateral triangle, the distance between wires being 24 inches. A telephone circuit of No. 12 hard-drawn copper is placed 5 feet below the power circuits. The power circuits are transposed every half mile, the telephone every five poles. No difficulty is experienced from inductance on the telephone circuit. The poles on the line are spaced 100 feet apart, and vary in length from 20 to 40 feet. Glass insulators of the Provo type, manufactured by the Hemingray Company, were used mounted on special locust pins which were boiled in paraffin. The cross arms are of Oregon fir, and angle-iron cross armbraces were used. Great care was exercised in the erection of the line, and up to the present time there has been no interruption of the service due to line trouble. The energy loss in the line when delivering 600 kw. to the mine is 8·5 per cent. At the receiving end of the line are three 180-kw. transformers of the vertical air-blast type, reducing the potential from 18,500 volts to 605. This apparatus is placed in a fireproof building with the electric hoist and a motor-driven air compressor of the Sargent-Ingersoll type 22½ by 14½ by 18 in., fitted with air regulator, and operated by a 150-h.p. induction motor. The receiver pressure is 90 lbs. The electric hoist is a double drum, and is arranged so that cages can be run balanced or independent as desired. The drums each carry 1,000 feet of 1-inch rope, and the rope speed is 840 feet per minute. The shaft has a slight incline. The weight of the cage

is 1,762 lbs., and of the loaded car 1,825 lbs. A 100-h.p. induction motor is geared to the hoist by means of a raw-hide pinion and operated at 450 r.p.m. By means of a controller the resistance in the secondaries can be varied, and direction of rotation reversed, and no sudden jerk is experienced in starting the cage. Three hundred and fifty tons of ore per day of 20 hours can be readily handled with this hoist from a 500-feet level. The crushing mill is in two sections, each section forming a complete mill for crushing, rolling, drying, and screening ore to 40 mesh, a 150-h.p. motor being belted to each section. The mill when treating 350 tons of ore per day requires a maximum of 230 h.p., this amount varying slightly with the character of the ore. The motors at the receiving end of the line are: One 150 h.p. for compressor, one 100 h.p. for hoist, two 150 h.p. for mill, one 20 h.p. for sawmill, two 20 h.p. for Feletin tanks, one 10 h.p. for solution pumps, one 10 h.p. for machine shop, one 1 h.p. for transformer blower, 10 h.p. for lights, making a total of 621 h.p. At the generating end the motors are: One 20 h.p. for motor-generator set, one 10 h.p. for coal conveyor, one 10 h.p. for ash conveyor, one 10 h.p. for coal crusher, one 1 h.p. for transformer blower.

At the pump-house, 14,000 feet from the power-house, there are two 10-h.p. motors running at 450 r.p.m., geared to triplex feed-pumps for forcing water up to power-house, and one 1-h.p. motor belted to an artesian deep well pump. This makes a total of 702 h.p. in induction motors. They are all supplied with oil switches and expulsion fuse blocks. The plant is for continuous service with an hour's stop for adjustment on Sundays.

E. H. C.-H.

1435. *Electric Power in the Olympia Mills.* (Eng. Record, 43. pp. 317–321, April 6, 1901.)—Two sets of plans were drawn up for this cotton mill, one suitable for electric-power distribution, the other for distribution by belts and shafting throughout. Tenders were obtained upon each, and the electric system proved the cheaper. It saved 10 per cent. on the mill buildings by the absence of the heavy transverse walls necessary with belts and shafting, 61 per cent. on shafting, and 66 per cent. on ropes and belts. The saving on these three items was more than sufficient, it is stated, to pay for the electrical equipment of the mill. The power is obtained from three three-phase generators, each of 1,300 kw. capacity, direct-connected to a McIntosh & Seymour engine of 1,600 i.h.p., and is distributed by means of induction motors through the mill. The paper contains a full description of the plant and the considerations that led to the adoption of the electric system of power distribution.

J. H.

1436. *Electricity Works of the Virginia Electrical Railway and Development Company, Richmond, Va.* (Elect. Rev., N.Y., 38. pp. 124–130, Jan. 26, 1901.)—The final equipment of the power-house will consist of eleven generating units, of which four are at present installed. These units consist of two 51-inch cylinder gate horizontal shaft turbines coupled to a 750-kw. direct-current 550-volt dynamo and an Allis tandem compound steam-engine rated at 700 h.p. A complete auxiliary steam plant is a necessary feature, although it is not thought that it will be required more than one month in the year under normal conditions. The balancers, booster, switchboard, feeder cables, &c., are described.

E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1437. *Sag and Strain in Trolley Wires.* **B. Hopkinson.** (Electrician, 46. p. 501, Jan. 25, 1901.)—Dawson has stated that a trolley wire of No. 0. B. & S. gauge should be so hung that the tension shall never, under any temperature that is likely to occur, exceed 2,000 lbs., corresponding to a sag of 3·8 inches on a span of 125 feet. If, therefore, the sag is 12 inches at 50° F. the wire will become dangerously tight if the temperature falls below the freezing-point. Wires are, however, generally put up tighter than this would imply. At Leeds on spans of 120 feet the sag in several cases was found to be as small as 8 inches, with a temperature of 50° F., and tighter spans are not uncommon. The author considers that this discrepancy between theory and practice is due probably to neglect of the elastic extension of the wire. Ewing found that with hard-drawn copper its natural length changes by 0·00085 per cent. per degree Fahrenheit, and that it stretches by nearly $\frac{1}{2000}$th part of its length for every 1,000 lbs. of tension up to 3,500 lbs., when the elasticity becomes imperfect. The following table has been calculated for a wire 0·4 inch in diameter, the supports being 120 feet apart. The actual length of the wire is s when hung at a

Sag. in.	Tension lb.	s/s'.	s/l.	Natural Length. (s' l.)	Expansion due to Temperature (t.)	Temp. (t.)
3	3,600	1·0018	1·00001	1 — (0·0018)	0	0°
4½	2,400	1·0012	1·00002	1 — (0·0012)	60	70°
6	1,800	1·0009	1·00004	1 — (0·0009)	90	105°
9	1.200	1·0006	1·00010	1 — (0·0005)	130	152°
12	900	1·00045	1·00018	1 — (0·00027)	153	180°
18	600	1·0003	1·00041	1·00011	191	220°

temperature of t° F.; s' is the unstretched length of the wire; l is the distance between the supports. The second column is calculated from the catenary given by the first, the tension depending only on the weight of the wire. The third column gives the ratio of stretching by virtue of the tension; the fourth is calculated from the properties of the catenary. The sixth column is the expansion of the wire due to rise of temperature in hundred-thousandths of its length. The last column is the temperature calculated from the expansion shown in the sixth. This table shows that wire hung so that the sag on a span of 40 yards is 6 inches at a temperature of 60° F. will never in this country be stretched beyond the limit of elasticity. The tension at 25° F. will be 2,400 lbs., and the sag 4½ inches; at 107° F. the sag will only be 9 inches. W. H. S.

1438. *Rating of Tramway Motors.* **A. H. Armstrong.** (Street Rly. Journ. 17. pp. 289–292, April, 1901.)—The author deals with the matter from a somewhat different point of view from that taken by Storer. [See Abstract No. 984 (1901).] He argues that it is only possible to arrive at satisfactory conclusions with regard to the performance of any motor after making careful observations on the motor under actual working conditions. The results obtained will depend partly on the length of the runs, and therefore indirectly on the number of stops per mile, partly on the efficiency of

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

the ventilation, and partly on other circumstances peculiar to the various cases. He therefore advocates a very careful examination of motors of the different types with a view to arriving at general conclusions. His method of testing is somewhat complex, but may be summarised as follows. He first constructs so-called acceleration curves, which have the time elapsed from the start of the car's run for abscissæ, and for ordinates (1) the speed attained in miles per hour ; (2) the amperes taken by the motor ; (3) the total distance travelled ; the speed curves being also completed so as to show the effect of coasting and braking with a view to bringing the car to a standstill in a given distance. A second set of curves is then constructed, having again the time elapsed for abscissæ, and for ordinates the average losses which have taken place during the various times in the armature and field, and also the ratio of the said losses in the said times. Having by observation determined the temperature rises in armature and field in the various times, he deduces the temperature rises per watt loss both in armature and field. Curves are then drawn showing the relation between the temperature rise per watt loss both in field and armature and the ratios of the losses in armature and field ; and it is pointed out that in an enclosed motor the interchange of heat between the field and armature is a matter for serious consideration. Finally a fourth set of curves is constructed showing the relation between the number of stoppages per mile and the number of tons a given motor will carry, the schedule speed maintained being also shown, and a temperature rise of 60° C. being allowed. In this way the author maintains that it will be possible to predict the results which a given type of motor will show under known working conditions, and considers that this method is far better than any form of workshop test. The figures and curves contained in the article were furnished by the General Electric Company of America, and were taken from tests made by them on their experimental track along the Erie Canal. The author in conclusion deals with the errors which may arise from the various forms of workshop test, and in particular from those advocated by Storer in the article already referred to. W. H. S.

1439. *Rosenfeld and Zelenay System of Electric Traction.* **L. Gerard.** (Soc. Belge Élect., Bull. 18. pp. 55-68, Feb., 1901.)—This system, which has been devised by two engineers of the Société "Electricité et Hydraulique" is called by them "tangential traction." It can only be operated economically on very high speed railways, the trains running at least 60 miles an hour. For speeds below this, the system is unsuitable, and would be very costly. It may briefly be described as follows. In addition to the ordinary rails, a second pair of light and insulated rails is laid between them, about 27 inches apart. Along the centre of the line rectangular blocks of laminated iron are fixed in the ballast at intervals of 55 yards. The length of each block is 11 yards. The blocks are arranged at a certain distance apart owing to the prohibitive cost of a continuous series. These blocks are wound with a three-phase winding, and may be regarded as constituting the stator of an induction motor. What corresponds to the rotor is a similar block of laminated iron, fixed on the axles of a truck that runs on the insulated rails, the said truck being beneath the main body of the car, and attached to it by hooks and chains. The winding of the rotor block is under the control of the driver, who can insert resistances at will. The air-gap between the rotor and stator is about two-fifths of an inch. The authors assert that an asynchronous triphase motor with an air-gap of this size has an efficiency of about 85 per cent. When, therefore, the stator blocks are excited by current from the

power-house, they exert a horizontal pull on the rotor blocks, which sets the train in motion. The propelling force on the train becomes practically very small unless the rotor block is immediately over a stator block, and the driving force is applied in jerks and not continuously. The loss of power that would be entailed by keeping the whole of the stator coils excited is obviated by dividing the line into sections of 550 yards, and exciting that section only on which the train is passing, the switching being done automatically by the train. The author gives an estimate for running trains at high speeds on this system, and according to these figures the system would be cheaper than the ordinary continuous current system. An experimental line is to be constructed. J. H.

1440. *Behr High-speed Railway.* **F. J. Behr.** (Soc. Arts., Journ. 49. pp. 305–312 ; Discussion, pp. 312–314, March 15, 1901.)—The author gives a description of the mono-rail line laid down by him at the Brussels exhibition, and then gives details of the proposed Manchester-Liverpool line, dealing more especially with the systems of signalling and braking. [Abstract Nos. 307 and 308 (1901).] *Discussion :*—**Carus-Wilson** criticised the brake, maintaining that it was impossible to obtain a retardation of $8\frac{1}{2}$ feet per second per second, which would stop the train in 500 yards ; the resistance to slipping on the rail at this retardation would have to be 600 lbs. per ton. He considered the practical limit to be 320 lbs. per ton, which would enable a retardation to be obtained of about $4\frac{1}{2}$ feet per second per second. **A. Cunningham** thought that on curves a tilt in the line was necessary for the comfort of passengers. **W. S. Boult** believed that considerable difficulty would be found in making the signalling contacts with the train at a speed of 110 miles per hour. **T. Carter** considered that the air resistance would contribute a considerable factor to the braking power. The author, in reply, said that according to his calculations the braking power required would not be nearly so much as that mentioned by Carus-Wilson. It might be found desirable to slightly tilt the rail, but on the Brussels line no discomfort was caused round curves of 540 yards at a speed of 85 miles per hour, and on the proposed line the smallest curve was 750 yards. The signalling contacts would be from 100 to 200 feet long, and had been designed for high speeds. G. H. B.

1441. *Breakdowns on the Berlin Tramways.* **J. Zacharias.** (Centralblatt Accumulatoren, 1. pp. 107–108, 1900.)—The heavy falls of snow last winter having occasioned breakdowns on the Berlin tramways, Albrecht, in the Elektrotechnische Anzeiger, attributes them to the use of Planté-type cells, and considers that pasted cells would be better suited to the mixed system employed in Berlin. The present article is a reply to Albrecht's, and endeavours to show that pasted plates could not be used under the conditions obtaining in Berlin, and attributes the breakdowns to the very great variation of pressure which occurred at the time of the snowstorms, the voltage on some days being so low that it was not possible to charge the cells. G. H. B.

1442. *Automatic Electric Block Signals on the Hungarian Southern Railway.* **O. Ehrenfest.** (Elektrotechn. Zeitschr. 22. pp. 216–220, March 7, 1901.)—In this system, the signals at each post are actuated by a weight motor, which has to be wound up twice a day by a signalman. The motion of this motor is controlled by two electromagnetic detents, one actuated by alternate

currents from a signal-box to set the arm to "line clear," while the other, actuated by a continuous current in a circuit completed by the train, sets the signal to danger. Photographs of the apparatus and a diagram of connections are given in the original paper. C. K. F.

1443. *Electric Platform at the Paris Exhibition, 1900.* **Jovignot.** (Soc. Int. Élect., Bull. 1. pp. 9–58, Jan., 1901.)—After outlining the history of moving platforms, the author describes the conditions under which the platform was constructed. The number of passengers provided for was 30,000 per hour; the main platform moved at the rate of 9 km., and the auxiliary at 4·5 km. per hour, and the total circuit was 3·37 km. in circumference. The structure was carried at a height of 7 m. on wooden piles with cross girders. The platforms consisted of two articulated chains of trucks, of which there were 1,700, carried by wheels running on steel rails; part of the weight was borne by a central girder running on wheels, of which 172 were motor-driven. The weight per metre of the 9-inch platform was 325 kg. light, and 885 kg. loaded; of the slow platform 150 and 290 kg. Various details of the electrical equipment are given; direct current was adopted, at 500 volts, the motors being of 5 h.p. each at 725 r.p.m., and having an efficiency at full load of 85 per cent. The distributing cables were calculated for a power of 600 kw. uniformly distributed, with a total loss of 8 per cent., requiring 42 metric tons of copper; the actual power was found to be 200 kw. Power was supplied through a substation containing two direct-current generators of 600 kw. each, coupled to three-phase 5,000 volt induction motors, with the necessary adjuncts.

On first starting the platforms, it was found necessary to divide the distributing cables into two equal lots, and to couple the motors two in series; as the speed was found to be sufficient, this arrangement was permanently retained, though the starting and running effort rapidly decreased with use. The platforms were operated successfully for 210 days, traversing nearly 19,000 km.; they cost 1,000 fr. per metre, inclusive, and transported seven million passengers in seven months. The total capital cost was 240,000 fr., and the running cost 180,000 fr. Full details of the construction are given in the paper, with particulars of the results obtained in working. A. H. A.

1444. *Electric Traction on Canals.* **L. Gerard.** (Soc. Belge Élect., Bull. 18. pp. 23–36, Jan., and 73–82, Feb., 1901.)—The author gives numerical data relating to various systems of electric traction, in tabular form, calculating the efficiency as the ratio of the power actually developed in the tow-rope to the electrical power applied. The Köttgen rack system on the Finow canal showed a maximum efficiency of 0·704 when towing a 100-ton barge at 3·75 km. per hour, the tractor working up to 20 e.h.p. at most, with an expenditure of 5¾ e.h.p. running light at 7·5 km. per hour. The Denèfle tricycle (old form) on the Aire and Deule gave an efficiency of 0·414 when towing a barge of 293 tons at 2·8 km. per hour, with a maximum power of 19·2 e.h.p. Running light at 3·74 km. per hour, the tricycle took 4·17 h.p. A new pattern of the tricycle gave an efficiency of 0·44 with the same load, at 2·64 km. per hour. The Gerard tractor gave 0·534 at 3·6 km., towing two 70-ton barges, and took 5·5 h.p. at 4·4 km. empty. Figures are given relating to the power absorbed by road friction. The Gerard screw-propeller system gave an efficiency of 0·322 at 3·2 km., the screw making 375 revs. per minute when towing two 70-ton barges, and took 5·4 h.p. at 8·2 km. empty. This

result is compared with steam practice, for which a maximum efficiency of 0·294 is given.

Discussing the figures given, the author points out that the cost of maintenance of the banks and of the tractors will in many cases more than outweigh the low efficiency of the electric towage system, while in addition the banks are often unfit to bear the weight of the tractors. Where these considerations do not hold, the rack system is the best, except for low speeds and loads, which are best handled by tractors without rails. The effect of the section of the canal and the strong influence of the current along it are next dealt with, and the very important question of the state of the tow-path is considered in detail; the loss due to rolling friction may amount to 35 per cent. By comparing figures obtained with animal haulage with those of electrical haulage, an increase of over 42 per cent. in the voyages annually made by a barge is shown in favour of the latter. In conclusion, the advantages gained by the electrical distribution of energy along the line of the canal, for lighting, pumping, dredging, and motive power in general, are emphasised. A. H. A.

1445. *Cleveland Electric Car.* (Automotor Journal, 5. pp. 267–269, March, 1901.)—A battery of 40 storage cells, each weighing 22 lbs. and of 130 ampere hours' capacity, supply the motive power to a 2 h.p. bipolar motor weighing 155 lbs. and running at 1,800 revolutions at 80 volts. The motor is normally connected to the axle of the driving wheels through a double reduction gear, but for hill climbing an extra reduction acting somewhat similarly to the back gear of a lathe can be introduced. Three speeds are obtained by coupling the cells four in parallel, two in parallel, or all in series, and then still higher speeds by shunting more or less of the field-magnet current. An electric brake effect is also provided for by a variable resistance through which the armature can be short-circuited. Diagrams of the electrical connections, and drawings showing the details of the transmission gear, are given. E. J. W.

1446. *Electric Motor-Car Trials.* (Electrician, 46, pp. 669–670, Feb. 22, 1901. See also Elect. Rev. pp. 388–390, March 1, 1901.)—This is the judges' report on the Automobile Club's trials at Chislehurst, and contains the results of the various observations.

The unanimous opinion of observers was that recuperation of cells downhill amounted to very little in practice. Considerable currents were returned, but for such short intervals that the saving of energy was practically nil. Indirectly, however, recuperation is of advantage to those batteries which tend to become polarised. E. H.C.-H.

1447. *Electrically-Driven Fire Cart.* **M. Schiemann.** (Centralblatt Accumulatoren, 2. pp. 79–81, March 1, 1901.)—The author has made a cart for conveying the first five firemen to a fire. Its tare is 1,000 kg. without its 600 kg. of battery, which will carry it for 15 km. in one hour. It is driven by a 4-h.p. motor, running at 1,500 r.p.m., driving a double bevel gear, which in turn drives the split front axle. The back axle is used for steering by means of a chain and quadrant. The average amount at 15 km. per hour on asphalt or macadam is 47 amps., at 85 volts (44 cells), which is equivalent to 0·13 kw.-hours per ton-km. The efficiency of the vehicle is 35 per cent. Another cart described will run at 20 km. per hour on the level. Each axle is driven through spur gearing by a motor, and can be moved separately on curves.

Both axles run and turn on ball bearings. The cart with motors weighs 4,000 kg., and the cells 1,500 kg., while fire apparatus, &c., will bring the total loaded weight up to 7 tons. Taking the traction-coefficient as 30 kg. per ton, the motors at 20 km. per hour must give about 20 h.p. or 14 kw. Each is rated at 9 h.p., or 12 h.p. maximum. The accumulators have 14 kw.-hours capacity, and the cart can go 20 km. in one hour. Allowing for battery inefficiency, the charge required is 21 kw.-hours, which at 10 pfg. per unit costs 2·10 Mk.; it will then go 20 km. at 20 km. per hour. Such a vehicle costs 12,000 Mk. Assuming that it makes 200 journeys a year of an average length of 5 km., the annual cost is:—

Interest, 5 per cent on 12,000 Mk.	600 Mk.
Depreciation and renewals, ditto	600 Mk.
Materials for repairs (labour being supplied from the ordinary fire staff)	500 Mk.
Maintenance and renewal of the battery, assuming 50 complete discharges per annum, say 20 per cent. of purchase price (3,400 Mk.)	680 Mk.
Cost of current, ($\frac{1000}{20} \times 2{\cdot}10$ Mk.)	105 Mk.
Battery losses when standing idle, say 15 per cent ...	15 Mk.
Total ...	2,500 Mk.
or 2·5 Mk. per km. run,	

which compares very favourably with horse traction. The Paris fire brigade has a complete equipment of electrically driven fire carts. Altona and Berlin have trial vehicles. E. H. C.-H.

1448. *Still Electric Vehicle.* (Automotor Journal, 5. pp. 261–263, March, 1901.)—The chief peculiarity of the vehicle is the manner in which the motor imparts its energy to the driving wheels. It is elastically suspended from a frame which is itself fixed across the centre of the main framework of the carriage. Both the field magnets and the armature revolve on ball bearings, and each of these parts is connected with a projecting shaft, terminating in a chain wheel. The one chain wheel is connected by a chain with the one driving wheel in the usual way, but on the other side of the vehicle the chain passes round the underside of the chain wheel and is carried by an idle wheel in front of it. Although the two motor shafts revolve in opposite directions both rear wheels are thus driven in the same direction. The motor is entirely enclosed as bipolar, and sliding contact rings and brushes are used for making the electrical connections to the revolving field magnet. It is series wound and the field magnet windings are divided into two parts, having different resistances. The armature has 30 sections and is of the slotted drum type. The weight of the 3 h.p. motor is 100 lbs., and the relative speed of the armature and field is 1,000 r.p.m when the vehicle is running at 12 miles an hour. The system of control which is employed consists in placing the battery in series, or in two parallels, and also in weakening the field by short-circuiting its higher resistance winding. Four speeds are in this manner obtained. The controller has two interlocking drums, one of which reverses the armature connections and the direction of rotation of the motor. The accumulators are known as the "Ideal" and are of the pasted lead type; drawings of these are given, and the capacity is said by the makers to be as high as 10 watt-hours per pound at a five-hour rate of discharge. A sectional drawing of the motor, and a diagram of the controller connections also accompany the description. A. G. N

ELECTRIC LAMPS AND LIGHTING.

1449. *Dick's System of Railway-train Lighting.* **E. Dick.** (Zeitschr. Elektrotechn. Wien, 19. pp. 78–80, Feb. 17 ; 89–95, Feb. 24 ; 101–104, March 3 ; and 115–117, March 10, 1901.)—This system is adapted for lighting single carriages, and is apparently a development of that described in Abstract No. 1416 (1898). It is shown fitted to a bogie carriage, from one of the axles of which the dynamo is driven through enclosed spur-gearing (speed-ratio = 1 : 3), whilst the accumulators are arranged in boxes suspended from the underside of the car-body. When the speed of the train exceeds 20 kilometres per hour the dynamo supplies the whole of the current for the lamps and charges the accumulators ; at lower speeds the accumulators supply the current for the lamps. The dynamo is 4-pole, of the ironclad type, and gives 30 amperes and 45 volts at speeds varying from 400 to 1,600 r.p.m., corresponding to speeds of from 23 to 93 kilometres per hour of the train. The controlling switch for cutting the dynamo into and out of circuit with the lamps was described in Abstract No. 703 (1901), whilst the regulating switch for cutting resistance into and out of the field magnet circuit to keep the potential difference constant is described in Abstract No. 1156 (1900). Relays are also provided, one for altering the sensitiveness of the pressure regulator when the accumulators are charged, and the other for reducing the loss of energy in the field-magnet circuit of the dynamo to a minimum when the train is not in motion. A switch is also provided for putting both accumulator batteries in parallel when the lamps are not in circuit so that the two batteries can be charged simultaneously, and for enabling one battery to be charged whilst the other is used as a pressure-regulator when the dynamo is supplying current to the lamps. The two batteries each consist of 18 elements, and are of a combined capacity sufficient to light the lamps for six hours without the aid of the dynamo. The accumulators are of the Wehrlin type in which measured amounts of active material are pressed, in a machine, into pastilles having a large number of perforations. These pastilles are first dried in the air and then in a stove, after which they are put into a mould and hard lead cast around them to form a grid. The plates are built into ebonite cells having ebonite covers. Nine of these elements are combined in a wood receptacle to form a half-battery, of which four are used in each carriage. After giving a detailed description of the operation the author gives the initial cost per carriage as follows : Dynamo and gearing, 1,800 crowns ; switches, fuses, and resistances, 1,200 crowns ; batteries, 1,120 crowns ; 14 roof-lamps, 470 crowns ; conductors and installation, 320 crowns, making a total of 4,910 crowns. The running expenses are as follows : Depreciation and interest at 7 per cent., 343·7 crowns ; maintenance, 173·15 crowns ; working expenses, 213·15 crowns, making a total of 730 crowns per annum. A similar estimate is made for local trains in which there is a dynamo at each end of the train and 56 lamps. In this case, the initial cost works out at 13,560 crowns, and the running expenses per annum are 1,900 crowns per train, or 135·74 crowns per carriage.

C. K. F.

REFERENCES.

1450. *The First Public Electromobile in Vienna.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 105–106, Feb. 14, 1901.)—A general description, together with an illustration, of this vehicle (a Victoria). Sixteen more of these are to be put at the disposal of the public shortly.

A. G. N.

1451. *Glow-Lamp Shades and Globes.* **W. L. Smith.** (Technology Quarterly, 13. pp. 176–223, 1900.)—This paper, after some rather valuable remarks on the lighting of rooms, &c., deals with the distribution of light of lamps fitted with 24 different forms of shades or globes. It is profusely illustrated with polar diagrams of the light distribution with the different forms, as obtained from photometric observations. E. C. R.

1452. *Advantages of Electric Traction.* (Union Int. Permanente de Tramways : Questionnaire, 1900, pp. 16–25. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 35–36 and 135–142.)—Figures of cost and receipts are given by various tramway companies for horse traction and for electric traction on the same lines before and after transformation. The matter forms the subject of a report by **E. de Pirch.** W. R. C.

1453. *Telpherage.* (Eng. News, 45. p. 105, Feb. 7, 1901.)—A brief description of the installation at the works of the Crocker-Wheeler Co., New Jersey. A. H. A.

1454. *Lighting of the Thames Embankment.* (Electrician, 46. pp. 689–692, March 1, 1901.)—A description of the arc lighting installation, driven by gas engines. A. H. A.

1455. *Electric Power at the Paris Exhibition.* **R. V. Picou.** (Soc. Int. Élect., Bull. 1. pp. 120–145, March, 1901.)—This paper deals with the generation and distribution of power within the exhibition buildings.

1456. *Electric Traction Experiments on the Belgian State Railways.* **E. Gerard.** (Soc. Belge Élect., Bull. 18. pp. 91–124 ; Discussion, pp. 124–126, March, 1901.)—A very full description of the preliminary electrical work which has been carried out on the Belgian State Railways, and the success of which has decided the Government to use electric traction on the whole of the Belgian railway system. Full particulars are given of the 100-h.p. gearless motors made by the International Electric Co., of Liège, and others ; also of the controllers, accumulators, &c. E. K. S.

1457. *Calculations of Networks.* **J. Teichmüller.** (Elektrotechn. Zeitschr. 22. pp. 229–231, March 14 ; 249–255, March 21, and 271–273, March 28, 1901. Paper read at the Kiel Meeting of the Verband Deutscher Elektrotechniker.)—The necessary calculations to determine the size of cables for electrical distribution are considered from fundamental principles and general formulæ are deduced. The paper concludes with an example applied to the installation at the Carlsruhe Technical High School. W. W. H. G.

1458. *Electric Lamps.* **E. de Fodor.** (Zeitschr. Elektrotechn. Wien, 19. pp. 165–168, April 7 ; and 180–183, with Discussion, pp. 184–185, April 14, 1901. Paper read before the Elektrotechn. Verein, March 6, 1901.)—This paper is mainly historical, dealing however in part with some of the latest developments, such as the Auer osmium lamp, the Nernst lamp, and Rasch's electrolytic arc lamp. W. H. S.

1459. *Value of Earthing.* **F. Uppenborn.** (Elektrotechn. Zeitschr. 22. pp. 370–372 ; Discussion, pp. 372–373, April 25, 1901.)—A paper read before the Verband Deutscher Elektrotechniker. W. W. H. G.

1460. *Electrical Power Bills of* 1900. **W. L. Madgen.** (Inst. Elect. Engin., Journ. 30. pp. 475–497 ; Discussion, pp. 497–508, and 514–539, April, 1901.)

TELEGRAPHY AND TELEPHONY.

1461. *Baudot Multiple Type-printing Telegraph.* **Grallert.** (Elektrotechn. Zeitschr. 22. pp. 282–293; Discussion, p. 293, March 28, 1901. Paper read before the Elektrotechn. Verein, Feb. 26, 1901.)—The author describes the Baudot telegraph as in use for the Paris and Berlin service for quadruple working. Its principle is as follows. Two distributing arms, rotating sychronously, one at the sending and the other at the receiving station, pass over four sets of five contacts; each set is in connection with a separate instrument, but it will be sufficient to consider one set only. The five contacts are electrically connected to five keys at the sending end, and to five electromagnets at the receiving end. The signals, corresponding to letters, consist of the 31 different combinations possible with the five keys—that is, to different combinations of five or less currents sent successively along the line; two change signals shift the type-wheel on the receiving instrument so as to print either letters or figures for any one signal, so that in all 58 different signals can be printed. The five electromagnets at the receiving end arrange five feelers, according to the combination signalled over the indented edges of two wheels fixed on the axis of the type-wheel, and continually rotating with it; at a certain point each feeler is over an indentation in one or other of the wheels, and all five sink together, thereby releasing a mechanism which presses the paper against the type-wheel and prints the letter corresponding to the signal. At the sending end the keys must be pressed exactly at the moment at which the rotating distributing arm begins to pass over the five contacts corresponding to the keys; to assure this an audible signal is given by a sort of telephone to indicate the correct moment for signalling; this is given by an extra contact inserted before each group of five, the distributer having therefore 24 contacts. As the contact arms make three revolutions per second, the time of any one current impulse is only $\frac{1}{72}$ second; the receiving relay must, therefore, be extremely sensitive and quick in action; it is a polarised relay of somewhat novel design, and is fully described in the paper with three drawings. The five electromagnets of the receiver act on five levers turning on five parallel axes; one end of these constitute the feelers which rest on the periphery of one indented wheel; the other ends are headed to bear one against the other in such a way that no feeler can sink into an indentation unless all five sink together. The electromagnets act on the levers in displacing them laterally, so that the feelers are transferred to the second indented wheel; indentations on one wheel correspond to projections on the other. Corresponding to each signal, that is, to each arrangement of the five feelers over the two wheels, is one position of the wheels, and with them of the type-wheel, in which an indentation is below each feeler, so that all can sink together; the sinking of the feelers releases a cam which presses the paper against the type-wheel and moves on the paper; a certain fraction of the periphery of the wheels is free from indentations, and is occupied by a snail which returns the displaced feelers to the wheel on which they normally rest. The periphery of the type-wheel is occupied (except on the corresponding portion left free) by 31 letters alternating with 31 figures, &c., and the change from letters to figures, and *vice versâ*, is effected by shifting the type-wheel relatively to its axis which

carries the indented wheels, the shifting being done by the cam which moves the paper. The distributor arm and the type-wheel at the receiving end are regulated to turn slightly faster than the sending distributor, and they are kept in synchronism by a brake applied by an electromagnet, which once in every revolution receives a correcting current if the arms are out of synchronism. The first regulation of speed is effected by a centrifugal governor acting on a brake. The distributor for single, duplex, and triplex telegraphy consists of six contact rings arranged on a single disc, while in quadruple and sextuple telegraphy two discs with ten rings are required. Three pairs of brushes rotate over each disc, each pair making contact between two contact rings. One disc is capable of a slight displacement relative to the other, to allow for the delay occurring between the line current and the consequent action of the printing magnets, due to the self-induction and inertia of the various relays in circuit. The disposition and connection of the contacts are very fully described in the paper, but cannot be dealt with in an abstract; they are arranged to work for sending and receiving, for the two brakes and for the signal. The paper contains a minute description of the whole instrument with 47 diagrams. G. H. B.

1462. *Burry Page printing Telegraph.* (Scientific American, 84. pp. 181–182, March 23, 1901.)—The feature of this apparatus consists in that the characters are printed in horizontal lines across the paper as on a typewriter. This is effected by means of five electromagnets arranged in two circuits, through which currents can be passed in both directions by means of suitable reversing keys in the transmitter [not described]. One of these magnets serves to wind up springs for rotating the type-wheel, for traversing the carriage bearing the type-wheel, and for effecting other operations. The other electromagnets control escapements for permitting the step-by-step rotation of the type-wheel and the traverse of the type-wheel carriage, and for actuating the paper-feed, consisting of an aligning device, consisting of a V-shaped tooth pressing into the spaces of a star-wheel, an impression device for bringing the paper into engagement with the type-wheel, and other mechanism. The original paper is illustrated, but more complete drawings and description will be found in the specification of British patent No. 19824 of 1900. C. K. F.

1463. *Selective Wireless Signals.* **P. Jégou.** (Comptes Rendus, 131. pp. 882–883, 1900.)—Two antennæ of different lengths are erected at the receiving stations and convey the waves to two coherers supposed to be of equal sensitiveness. By means of a differential bobbin the windings of which are respectively connected to the two receiving coherers, the effects on the galvanometer neutralise one another when both antennæ act, and are only noticeable when one coherer is affected. M. O'G.

1464. *Wireless Telegraphy.* **F. Braun.** (Electrician, 46. pp. 778–779, March 15, 1901.)—This paper is a summary of two lectures delivered by the author at Strassburg on November 16, 1900, and January 31, 1900. The author describes a method devised by himself of exciting the transmitter by induction. Condensers with a capacity of the order of the usual size of Leyden jar are discharged through a primary circuit with self-induction; this circuit excites oscillations in the lower spirally wound end of the transmitter. The transmitter is insulated from the earth, and is sparkless. The author claims the following advantages: (1) In the primary circuit a large amount of energy can be employed usefully; the action of the transmitter increases with the

energy employed to a much greater extent than with the Marconi connection, and can be increased by employing greater capacity or higher potentials. (2) The oscillations of the transmitter are not dangerous. (3) Insulation of the transmitter is not so important as with Marconi connections. (4) The oscillations in the primary circuit are but slightly damped, and those in the transmitter still less so, consequently, if the two circuits be brought to resonance, the amplitude of the oscillations becomes very large. (5) The arrangement fulfils the fundamental conditions for tuning between a transmitter and receiver.

Particulars are given of experiments in signalling, made with a view to comparing the author's arrangement with Marconi's. With inductive excitation signals were transmitted from Cuxhaven to Heligoland, a distance of 63 km., with masts 29 and 31 m. high, while with Marconi connections not a single signal was observed. The author mentions a method of tuning by concentrating the energy on the receiving appartus. G. H. B.

1465. *Telephone Switchboard, M.* 99, *of the German Post Office.* (Elektrotechn. Zeitschr. 22. pp. 382–384, May 2, 1901.)—This switchboard, which is very extensively used, is designed for 50 subscribers with complete metallic circuits; it is, however, arranged so as to work with earth returns for some of the subscribers, this being effected by means of a double plug and jack, from which insulating sleeves are taken when it is desired to work with an earth return. Diagrams of connections and photographs of the apparatus are given in the original paper. C. K. F.

1466. *Combination Switch for Telephone Intercommunication Systems.* **L. Montillot.** (Electrician, 21. pp. 179–182, March 23, 1901.)—This switch is devised by I. Tournaire, and replaces jacks, plugs, cords, and lever commutators. A plunger, with a vulcanite head, works in a socket of ivorine, and, when pressed home against the spring which spirally encircles it, makes, against the bottom contact, the requisite movement for putting a battery current in circuit for the call. Upon releasing the plug or plunger it resumes its normal position. To select one of the four circuits for which it is adapted, the vulcanite head is turned round to the requisite position, a double spring under or on the base of the switch moving round simultaneously and engaging the brass terminals allotted to the various lines. An arrow mark is engraved on the surface of the vulcanite head, which shows the position at any time of the switch spring within. In order that this spring may not overrun the contacts, by an incautious turn of the head or button, a small projecting hook or nose, attached to the stem of the plunger, rides over a small stud at each quarter turn of the button and settles into position between two adjacent studs when the movement is complete. Thus the operator is made sensible, by this snap action, of the proper contacts being effected. This switch can evidently be used at a central station from which branch lines radiate, or for intercommunication purposes. E. O. W.

REFERENCE.

1467. *Central Battery Telephone System.* **H. André.** (Ind. Élect. 9. pp. 545–548, 1900. Paper read before the International Electrical Congress at Paris.)—Description in general terms of the Western Electric Company's Central Battery Telephone System, with comparison between the old and new systems. [See further Abstract No. 330 (1901).] J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1901.

GENERAL PHYSICS.

1468. *Hardness of Metals and Alloys.* **C. Benedicks.** (Zeitschr. Phys. Chem. 36. pp. 529–538, April 2, 1901.)—It has been shown that the hardness of steel depends on the carbon, in the form of carbide (C_2Fe_6), forming a homogeneous solid *solution* with the iron, the carbide being only mechanically *mixed* with the iron in soft steel. As in general a solvent increases but little in volume on dissolving small quantities of foreign substances, such solution increases the number of atoms present in a given volume, or the atomic concentration (density ÷ atomic weight). Bottone has shown that for twenty-four pure metals the hardness measured in a certain way is proportional to the atomic concentration, and other measures of hardness seem to confirm this conclusion. But, by Avogadro's law, atomic concentration in gases determines their pressure, and analogy therefore suggests that hardness in simple bodies may be of the character of a pressure, by which indeed under Herz's definition it is measured. The hardness of solid solutions, *i.e.*, of alloys, will thus be of the nature of an *osmotic pressure*; and this conclusion explains the facts of the varied hardness of iron when alloyed with different metals, and those, too, of the hardness of Cu-Sn alloys. R. E. B.

1469. *Determination of Gravitation Constant.* **J. F. Hayford.** (Science, 13. pp. 654–655, April 26, 1901.)—After reference to the differences between the results obtained in the absolute measurement of the gravitation constant by different observers at the same station using different instruments, the author outlines the system of comparative determinations which have been arranged by the International Geodetic Association from observations at Washington, Kew, London, Greenwich, Paris, and Potsdam. C. P. B.

1470. *Mercury Vacuum Pump.* **R. Federico.** (N. Cimento, 1. pp. 187–189, March, 1901.)—Guglielmo described a pump [Abstract No. 5 (1900)] acting by means of a Torricellian vacuum, but having the disadvantage that its working required the use of two stopcocks. The pump described in the present paper is constructed on the same principle, but does away with the necessity of stopcocks. The principal bulb exhausts into a second bulb, from which it is shut off by a mercury seal in a U-tube, the second bulb being exhausted simultaneously, so that between the two there is but a small difference in pressure. G. H. B.

1471. *Pyknometer.* **M. Rudolphi.** (Phys. Zeitschr. 2. pp. 447–448, April 27, 1901.)—This instrument is intended for comparing the densities of two liquids. It consists of two concentric tubes of glass, closed at each end so as to form a jacketted cylinder. The ratio of the volumes of the inner and outer vessels can be very simply expressed. A sketch of the instrument is given, but there are no details as to the method of using it. R. A.

1472. *Superficial Tension: Drop Methods.* **P. A. Guye** and **F. L. Perrot.** (Archives des Sciences, 11. pp. 225–265, March, and 345–388, April, 1901; also Comptes Rendus, 132. pp. 1043–1046, April 29, 1901.)—Investigations are made into the conditions under which superficial tensions measured by drop methods would be really comparable with those obtained from capillary ascents in vacuo. A critical discussion is given of the bibliography of the subject. The weight of drops of the same liquid issuing from the same orifice is not the same for slow and for rapid formation of the drops; under ordinary conditions, as drops are formed more rapidly they become heavier. As the time of formation of the drop is lengthened the weight reaches a limit, beyond which any further lengthening of the time makes no difference; but even under these conditions the superficial tensions as calculated do not agree any better with those derived from capillary ascents, and no method of correction has as yet shown itself to be applicable. When we discriminate between drops completely formed and drops fallen off, we find that these are not always proportional to one another, and the liquid remaining adherent after the fall of the drop represents a fraction which varies from one liquid to another between 17 and 29 per cent. The best method for measuring superficial tensions by drop methods seems to be that of M. Duclaux, to let the drops form freely at the capillary orifice of a pipette calibrated beforehand with a standard liquid whose superficial tension is known. By introducing two corrections, one of which depends on the number of drops, the other on the rate of their succession, the superficial tensions may be obtained within 1 or 2 per cent., which is enough when the object in view is to ascertain whether the liquid studied has become polymerised or not. Many points remain for further investigation, which is promised. A. D.

1473. *Resistance of Air at Speeds below One Thousand Feet per Second.* **A. F. Zahm.** (Phil. Mag. 1. pp. 530–535, May, 1901.)—The projectiles used were wooden spheres about 4 inches diameter of different masses. Instead of making the balls break wires stretched across their path at different distances from the gun in order to measure the velocity, the wires were replaced by very narrow beams of light, and the chronograph was of the form of a photographic plate falling freely under its own weight.

The results are found to satisfy the formula $R = av^2 + bv^3$, deduced theoretically in 1842 by Duchemin. When expressed in lb. ft. sec. units the formula becomes—

$$R = 0{\cdot}000008v^2 + 0{\cdot}000000049v^3.$$

J. B. H.

1474. *Work of the Reichsanstalt in* 1900. (Zeitschr. Instrumentenk. 21. pp. 105–121, April, and 138–155, May, 1901.)—This summary of the work done during the year 1900 in the Reichsanstalt is divided into two parts, dealing with the work of the Research department and the Testing department respectively. The list of researches done in the former under the heading Heat includes density of water vapour at 100° C., density of water vapour at

room temperature, vapour pressure of water vapour at 50°, measurements of high temperatures and determination of melting-points of a number of metals, expansion of metals at high temperatures, measurement of low temperatures by a petrolether thermometer and standardisation of the platinum thermometer at the same temperatures, heat conductivities of metals, conductivity of heat through hot surfaces, and work with Fizeau-Abbe's dilatometer. The electrical researches are: Construction and standardisation of standard resistances and standard cells, measurement of the capacity of an air condenser by Maxwell-Thomson method, and conductivity of solutions. The optical researches have all been connected with radiation.

The second part, extending to fifteen pages, which deals with the work of the Testing department, contains little more than lists of the various instruments tested during the year; but where improvements have been made in the methods of testing a short description of the same is given.

Abstracts of many of the researches have already been published in these pages. The number of persons engaged in the Reichsanstalt is 96, 35 being scientific workers, 41 technical workers, and 20 clerks and subordinates.

J. B. H.

1475. *Theory of Capillarity.* **G. Bakker.** (Zeitschr. Phys. Chem. 36. pp. 681–692, April 19, 1901.)—This is a treatise on the differential equation of capillarity. We are to suppose a homogeneous medium the parts of which behave to each other as regards their mutual forces as the various molecules or atoms in capillary phenomena. If these mutual forces have a potential, it must in the interior vary as the density, and in the exterior space diminish rapidly to zero along the normal to the bounding surface. These conditions are expressed for the potential V by the equation $\nabla^2 V = q^2 V + 4\pi f\rho$, where ρ denotes density, and q and f are constants, provided q be great enough.

The author proceeds to transform this equation by means of a system of curvilinear co-ordinates, whose elements are ∂u, ∂v, ∂n. He obtains the result—

$$\partial\frac{\frac{dV}{dn}}{\partial n} + \left(\frac{1}{R_1}+\frac{1}{R_2}\right)\frac{\partial V}{dn} = q^2 V + 4\pi f\rho,$$

where R_1, R_2 are the principal radii of curvature to the surface to which ∂n is normal.

He then considers the molecular pressure and surface tension. The former can be calculated from the last written differential equation. In the special case of no external forces the uv surface is a level surface of the potential of the capillary forces. As in his former papers the author discusses the relation between V as defined by the above equation and Laplace's constants K and H, remarking that Laplace assumes the density of his liquid to be constant up to the boundary. In the present paper the constancy is assumed only within the capillary layer.

In his concluding section he introduces the surrounding medium—*e.g.*, vapour of the liquid—into the theory, assuming it not only to exert uniform pressure on the surface, but to contribute to the potential V. This is discussed with reference to the theories of Laplace and van der Waals. S. H. B.

1476. *Vitrified Quartz.* **W. A. Shenstone.** (Nature, 64. pp. 65–67, May 16, 1901. Paper read before the Royal Institution, March 8th.)—A lecture on the preparation and properties of vitrified quartz. The author describes his

method of making tubes of this material, pointing out the difficulties to be overcome. When once prepared, these tubes are for many purposes much superior to glass tubes, as, for example, for use in thermometry. The mean coefficient of expansion of a rod of vitrified silica is only 0·000,000,59 ; its expansion is exceedingly regular up to 1,000°, and if not heated beyond this temperature it returns very exactly to its original length when cold. Above 1,000° the rate of expansion diminishes rapidly, changing to a contraction at about 1,200°. Experiments on the transparency of this substance to ultra-violet rays show that tubes made of it are much more suitable than glass ones for use in studying the spectra of electric discharges. Its most remarkable property is its behaviour under sudden changes of temperature. When white hot it may be plunged into cold water, or even into liquid air, without injury. For use in thermometers, and for researches on pure gases and on the behaviour of gases at high temperatures, it should prove much superior to glass. It has some defects, however, as it is slightly permeable to hydrogen at about 1,000°, and it is attacked, when hot, by alkaline oxides. W. C. H.

1477. *Mechanical Compensation for the Rotation of the Field in the Siderostat and Heliostat.* **A. Cornu.** (Comptes Rendus, 132. pp. 1013–1017, April 29, 1901.)—The fact that these instruments only bring one point of the field to rest, while the other points revolve round it, causes inconvenience, especially in photographic work. Devices, practical and theoretical, have recently been brought forward for counteracting the rotation of the field by imparting an equal rotation to the photographic plate. The author points out that the problem can be solved by means of the well-known mechanism called Hooke's joint (*"joint universel, ou croisillon"*). If the rotations round the two axes of a Hooke's joint are measured from properly chosen zero points, the tangents of the rotations are in a constant ratio, this ratio being the cosine or secant of the inclination of the axes.

The rotation of the field of the siderostat is governed by the relation—

$$\tan\frac{Y}{2} = K\tan\frac{H-\omega}{2}, \text{ with } K = \frac{\cos\frac{1}{2}(\rho+\delta)}{\cos\frac{1}{2}(\rho-\delta)},$$

Y being the rotation of the field, ω the hour-angle of the fixed reflected ray, H the hour-angle of the corresponding incident ray. The two axes of the Hooke's joint must be set at an angle whose cosine or secant is equal to K. This solution has the advantage of only involving rotations about pivots, which are easily realised and involve a minimum of friction. The adjustments necessary for securing accuracy would, however, be troublesome to carry out (though not more so than in the other methods which have been proposed). This is the reason why the author, who has long been familiar with this solution, has not published it before. A. E.

1478. *Comparison of Photographic Magnitudes of Stars of Different Colours.* **K. Schwarzschild.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 1127–1134, 1900.)—In comparing the photographic effect of light of different colours, a difficulty is met with analogous to the Purkinje phenomenon in visual optics (by which the red end of the spectrum appears to grow brighter relatively to the blue as the intensity of the light increases). Two differently coloured sources which, in the same time, darken the film to the same extent, will no longer do so when the time is altered, or when the intensities of both sources are increased in like proportion. The effect, however, is largely masked by the superior sensitiveness in the blue (max. about 450$\mu\mu$) of the silver

bromide plates in common use. In considering celestial photographs one might expect the effect to be negligible except for decidedly red stars. With the view of testing how far this was the case, the author selected several close pairs of stars, in which the components of each pair, while nearly equal photographically, differed in visual brightness (in some cases by more than a magnitude). Each pair was photographed with a series of exposures ranging from 30 seconds to 1½ hours, on plates placed at two different distances from the focus. No alteration in the relative photographic magnitude of the components was found under these circumstances for any pair. The author makes frequent use of the term "relative actinity," which he defines as the ratio of the photographic brightnesses of two sources divided by the ratio of their visual brightnesses. A. E.

1479. *Magnetic Theory of Solar Corona.* **F. H. Bigelow.** (Amer. Journ. Sci. 11. pp. 253–262, April, 1901.)—The probable connection between the form of the solar corona and the discharge from an electrified conductor when subjected to a magnetic field has been urged at various times since 1889 by the present author and others. Discussion of the measures obtained from the coronal pictures obtained in 1898 and 1900 tends to greatly confirm this view, and a discussion is given in the paper of the probable effect of magnetic disturbances at the sun's surface on the meteorological phenomena on the earth. It is pretty generally accepted that the electrical state of the atmosphere is associated with the varying tension of water vapour, and the distribution of water-vapour zones is described in this connection, a process of ionisation of the particles of water vapour being supposed to be induced by the magnetic radiation from the sun.

The paper also contains useful references to the experimental work of Pupin, Ebert, Elster and Geitel, and others. C. P. B.

1480. *Solar Radiation.* **J. Violle.** (Annal. Chim. Phys. 22. pp. 329–370, March, 1901. Report presented to the International Meteorological Committee at St. Petersburg in 1899.)—The report is in two parts, preceded by a brief historical review of the chief methods employed for determining the solar radiation. The first part contains descriptions, not illustrated by diagrams, of some instruments and notes on their application, namely instruments of Violle, Crova, Angström, &c. The second part contains a discussion of formulæ. We have now excellent observatory apparatus for the determination of solar radiation, and also portable instruments, but no meteorological instruments of sufficient simplicity and strength. Owing chiefly to the unknown absorption in the higher atmospheric strata, the solar constant remains uncertain. Further balloon observations at high elevations are needed. H. B.

1481. *Age of the Earth.* **P. Rudzki.** (Acad. Sci. Cracovie, Bull. 2. pp. 72–94, Feb., 1901.)—The writer refers to Joly's memoir on the same subject, to R. O. Fisher's comment thereon, and to Kelvin's discussion given in Thomson and Tait's "Natural Philosophy," Appendix A. According to Fourier's theory of heat, if the temperature in a sphere of radius R gradually cooling be a function of the distance from the centre, the contraction is expressed by—

$$\frac{dR}{dt} = -\frac{3\mu k}{\gamma},$$

in which k is the coefficient of thermal conductivity, γ the gradient of tem-

perature in the superficial layer, and μ the coefficient of linear dilatation with increase of temperature. It is assumed that at a time $t=0$, which must have been before the commencement of the Silurian age, the earth was at uniform temperature : $t = t_1$ denotes the commencement of the Silurian age, and $t = t_2$ the present time. The object is to find a value for $t_2 - t_1$, which shall be, if not approximately correct, at least correct as regards order of magnitude.

According to Kelvin we take $\gamma = c\sqrt{t}$,

whence— $\gamma_1 = c\sqrt{t_1}$ $\gamma_2 = c\sqrt{t_2}$,

or— $c = \gamma_2/\sqrt{t_2}$.

And γ_2 is known by observation. If ΔA be the diminution of the earth's surface by contraction since the beginning of the Silurian age, we find—

$$\Delta A = \frac{48\mu k\pi R}{\gamma_2}\sqrt{t_2}(\sqrt{t_2}-\sqrt{t_1}),$$

whence— $$t_2 - t_1 = \frac{\gamma_2}{48\mu k\pi R}\cdot\frac{\sqrt{t_2}+\sqrt{t_1}}{\sqrt{t_2}}\Delta A,$$

and the maximum value of $\frac{\sqrt{t_2}+\sqrt{t_1}}{\sqrt{t_2}}$ is 2 if $t_1 = t_2$, and its minimum is unity if $t_1 = 0$. The former limit corresponds to the hypothesis that $t_2 - t_1$ is infinitely small compared with t_2 or t_1, and that γ_2 may be treated as constant with regard to time. The limit $t_1 = 0$ corresponds to the hypothesis that at the beginning of the Silurian age the earth's temperature was constant.

To calculate ΔA the author assumes that the diminution of surface area is equal to the area of the foldings which have taken place since the epoch in question, and this he essays to calculate from known geological data respecting the various continents and islands and the depth of the adjoining oceans. Taking the lowest estimates, he finds—

$$\Delta A = -8{,}080{,}000 \text{ square kilometres.}$$

He then considers the coefficients μ and k, as to which there is much uncertainty. On the hypothesis $\frac{\sqrt{t_2}+\sqrt{t_1}}{\sqrt{t_2}} = 1$, the estimates vary from $t_2 - t_1 = 478{,}000{,}000$ years to Perry's estimate, 9,600,000.

The above discussion is on the assumption that the earth is to be treated as solid throughout. The writer concludes with a discussion of the difference which will be caused by the assumption that it is liquid or gas. S. H. B.

1482. *Air Barometer.* **H. A. Naber.** (Ann. d. Physik, 4. 4. pp. 815–827, April, 1901.)—After some historical notes the author gives descriptions of three barometers of his own. The first indicates barometric variations, and consists of a cylinder, fitted with cocks above and below, immersed in water or petroleum ; a coil, surrounding the cylinder, starts from below the upper cock, and is open at its lower extremity. The second instrument is a tubular pocket barometer on Hooke's principle, partly filled with water and containing an air and a mercury thermometer so adjusted that their relative heights remain unaffected by temperature. The third is a hydrogen voltameter based on Boyle's law ; it was described in *The Electrician* (1894).

H. B.

LIGHT.

1483. *Transparency of Hydrogen.* **V. Schumann.** (Ann. d. Physik, 4. 3. pp. 642–645, March, 1901.)—Photographs were taken of that part of the spectrum of wave-length under 185 $\mu\mu$ with and without the hydrogen present. When an indiarubber tube of 50 cm. long connected the absorption tube and the apparatus for generating the hydrogen, the transparency of the hydrogen appeared to have suffered. When the rubber connecting tube was replaced by a glass one the hydrogen seemed more transparent than the vacuum which was alternated with it in taking the photographs. This is accounted for by the presence of vapours of mercury and fat in the exhausted absorption tube which would not be present to the same extent when the tube was filled with hydrogen at atmospheric pressure. E. H. B.

1484. *Influence of Temperature on the Absorption of Light by Solids.* **J. Koenigsberger.** (Ann. d. Physik, 4. 4. pp. 796–810, April, 1901.)—The influence of temperature on the absorption of light by various solids has been experimentally determined for the temperature interval 10°–360°. Three different forms of spectral photometer were used; the final and most accurate form (0·4 per cent.) will be described in another paper.

The experimental results are summarised as follows:—

(1) In solid bodies having a selective absorption a rise of temperature moves the absorption curve in the direction of the longer wave-lengths, and in some cases simultaneously increases slightiy the width of the absorption band; the magnitude of the maximum absorption is not appreciably altered.

(2) In metals the absorption is not influenced by temperature within the limits 10°–360° (for platinum up to 800°).

The author deduces from these experiments the influence of temperature on the refractive index and the dispersion in qualitative agreement with experimental results under the assumption that the dielectric constant always diminishes with increase of temperature. Some considerations are also added as to the light which a body should emit when heated. J. B. H.

1485. *Interference Bands Produced by a Thin Wedge.* **H. C. Pocklington.** (Cambridge Phil. Soc., Proc. 11. pp. 105–106, April 22, 1901.)—If light from a monochromatic source be caused to fall on a thin wedge of air contained between two pieces of glass which are kept apart at one side by a piece of paper but touch at the other side, interference bands are produced. The author discusses the conditions necessary for the bands to be clear and well defined, and deduces the formula connecting the angle of the film, the angle of incidence, and the distance between the bands. He has subjected his formulæ to experimental verification, and using rough apparatus has obtained results correct to about 1 per cent. W. C. O.

1486. *Graphical Study of Deviation by a Prism.* **P. Lugol.** (Journ. de Physique, 10. pp. 339–341, May, 1901.)—In the following, i, i' are the angles of incidence and emergence; r, r' the corresponding angles within the prism. To find the deviation, draw the curve of sines $y = \sin x$ (1), and also the curve $y = \frac{1}{\mu}\sin x$ (2), μ being the index. Let a line Pp, parallel to the axis of x, cut (1) at p, and (2) at P; and let n, N be the feet of the

ordinates at $\hat{P}$, P. Then sin ON $= \mu$ sin On, and hence if ON $= i$ we have O$n = r$, and Nn is the deviation at the first face. Let M, m be the feet of ordinates at points where a second line parallel to x cuts the two curves. Cut off OA on the axis of x equal to half the angle of the prism. Now if m and n be at equal distances from A on opposite sides, then O$m = r'$ (since $r + r'$ = angle of prism = 2OA). Hence OM $= i$, and Mm = deviation at second face. An ordinate is erected at N equal to Mm + Nn, the whole deviation, and its end traces a curve showing variation of deviation with incidence-angle. Various properties are deduced from the construction. A. E.

1487. *Double Refraction in Liquids.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 3. pp. 161–171, March, 1901.)—The author discusses the theory of accidental double refraction in liquids, examining only that part of the problem which can be attacked by the principles of hydrodynamics alone. He imagines a cylinder capable of rotation upon its axis. Concentric with this and at a little distance from it is another fixed cylinder, the space between the two being filled with the liquid under examination. He supposes the liquid incompressible and equations are established from which the deformation can be calculated. If the liquid be traversed by a beam of light parallel to the axis the double refraction resulting should be proportional per unit length to the true deformation. He draws the conclusion that there is no foundation for supposing that the accidental double refraction in a liquid depends only on its viscosity. W. C. O.

1488. *Optical Activity of Ethers and Esters.* **P. A. Guye.** (Chem. Soc., Journ. 79. and 80. pp. 475–476, April, 1901.)—The rotatory power of benzyl amyl ether resembles that of the *n*-butyl, rather than the phenyl or tolyl amyl ethers, and similarly amyl phenylacetate and phenylpropionate resemble the chloroacetate and propionate, rather than the benzoate and toluates. These are special cases of the general law that when substitutions of chains or groups of elements are effected in an asymmetric carbon compound in positions sufficiently far removed from the asymmetric carbon atom, the rotatory power is only slightly affected. T. M. L.

1489. *A New Interference Method of Resolving very close Spectrum Lines.* **O. Lummer.** (Deutsch. Phys. Gesell., Verh. 3. 7. pp. 85–98, 1901.)—In a former paper (Wied. Ann. 23. pp. 49–84, 1884) the author discussed the interference rings seen on looking through a very truly parallel transparent plate at a homogeneous light of measurable dimensions, with the eye accommodated to infinity, or, better, with a telescope. (See Drude's Optek, pp. 134–145.) To the properties previously enumerated he now adds another —that mentioned in the title. These rings are due to interference of rays reflected at the two surfaces, and the difference of phase depends only on the inclination of the rays to the normal. The difference between consecutive rings alters with this inclination, being least for some value between 0° and 90°. If the source of light be duplex, each component has its own set of rings, and the appearance of the component system changes with the angle of incidence, for certain values of which the maxima of one system fall on the minima of the other. The coincidence, however, is not necessarily exact; the two systems will only extinguish one another completely under certain conditions. The author examined the yellow lines of the Hg spectrum with an apparatus arranged in the following order: Mercury lamp, collimator tube, Rutherford prisms, small adjustable opening, large

glass plate 5·3 mm. thick, telescope. It was found best to arrange the prismatic dispersion so that, with fairly wide slit, lines three times as far apart as the D lines were separated. Now Perot and Fabry have shown that each of the two yellow Hg lines has a faint and very close companion. The author calculated the appearances which ought to be presented by the complex system of rings due to the principal lines and their faint companions. The results of observation were in complete accordance with the prediction. With incidence sufficiently oblique, in both yellow images of the slit, besides the principal bands, auxiliary interference bands were seen, their relative positions being different in the two images. Observations were also made with reflected and polarised light. Other methods of producing the rings are described, and kindred investigations by Michelson and by Perot and Fabry are discussed. It is pointed out how the variation of intensity and the sharpness and resolving power of the rings may be calculated. A. E.

1490. *Anomalous Dispersion of Carbon.* **R. W. Wood.** (Phys. Soc., Proc. 17. pp. 657–663, July, 1901; and Phil. Mag. 1. pp. 405–410, April, 1901.)—The author, in attempting to determine whether the rapid decrease in amplitude of the wave front resulting from the passage of a wave through a prism of some strongly absorbing substance had any influence upon the direction of propagation of the ray, had recourse to a film of smoke on glass, hoping thereby to obtain a substance which would cause a decrease in amplitude without retardation or change of phase. The result, however, showed a very marked retardation. This the author suggests might be due to diffraction, an increase of path being introduced owing to the passage of the light round the carbon particles. If this were the true explanation, in such a film dispersion should be absent, or else there should be a greater retardation for the long waves than for the short.

A prism of finely divided carbon was constructed by taking a piece of plate glass and passing it slowly backwards and forwards over a flame, and the prism so formed was judged by the regularity of the interference pattern which it exhibited by reflected light. Having procured a suitable one, it was covered with a piece of paper perforated with two rectangular openings of equal width, one being placed over the smoked portion, the other over the unsmoked portion.

The prism was then placed upon the stand of a spectrometer, and the opening over the smoked portion closed, and the position of the image of the slit noted, this, of course, being undeviated. This opening was then closed and the other opened, and the position of the image of the slit produced by the light which has passed through the carbon prism read off. This was done with both blue and red light, and the mean for blue was found to be 43·6, while for red the mean deviation was 57·2. Thus the long rays show greater retardation than the short ones. The deviation produced was about 43 seconds. The results obtained are what would be expected if the diffraction theory were true, though they do not prove it. W. C. O.

1491. *Lamps for Spectrum Analysis.* II. and III. **E. Beckmann.** (Zeitschr. Phys. Chem. 35. pp. 443–458, and 652–660, 1900.)—In Part II. the author describes various auxiliaries for use with the lamp devised by him, such as apparatus for cooling the solution and washing the trough, various arrangements for forcing the air through the porous tubes, &c.

Part III. contains descriptions of a "universal lamp" for observations with the flames of coal-gas, hydrogen, or detonating gas, and of a sodium lamp for demonstration work. [See also Abstract No. 2419 (1900).] T. H. P.

1492. *Spectra with Self-Induction Spark.* **G. A. Hemsalech.** (Comptes Rendus, 132. pp. 959–962, April 22, 1901.)—A long series of experiments are described showing the gradual changes in the spectrum of an electric spark when the self-induction in the secondary circuit is varied. Photographs of many of these are given with the paper.

From the differing behaviour of the various lines the author distinguishes three classes of spectrum lines :—

(1) Those lines whose intensity diminishes rapidly with increase of self-induction. These are the lines of air and the high-temperature or short lines of metals, *e.g.*, the doublets of zinc and cadmium ; 4481 magnesium, 4244·9 and 4386·6 of lead.

(2) Those lines which slowly diminish in intensity and in a continuous manner with increase of self-induction. These correspond to the arc lines of the metals, *e.g.*, the triplets of magnesium.

(3) The lines which diminish at first to a minimum, and then begin to increase again as the self-induction is further increased. The greater number of the lines of Fe and Cu belong to this class.

[See also Abstract No. 2159 (1900).] C. P. B.

1493. *Villari's Osbservations on Electrical Discharge by Röntgenised Air.* **E. Dorn.** (Phys. Zeitschr. 2. p. 433, April 20, 1901.)—From Zeleny's experiments on the velocity ratio of positive and negative ions in an electrical field, for air and damp carbon dioxide, the author deduced that in Villari's experiments these gases would give discharges of opposite sign. [See Abstract No. 800 (1901).] Villari [see Abstract No. 1072 (1901)], however, found the discharges to be of the same sign, but weaker in the case of carbon dioxide. In the meantime, the author found that the ratios given by Townsend [see Abstract No. 59 (1900)] and Chattock, Walker and Dixon [see Abstract No. 848 (1901)] differed from Zeleny's, and, taking the latter's figures, his deductions agree with Villari's experimental results. He recommends that Villari's apparatus be constructed throughout of the same metal. G. H. B.

1494. *Action of Radium Rays on Selenium.* **E. Bloch.** (Comptes Rendus, 132. pp. 914–915, April 15, 1901.)—Following Smith's discovery that the resistance of selenium is lessened by the action of light, Perreau has shown that Röntgen rays have a similar action [Abstract No. 628 (1900)]. In the present paper it is shown that radio-active substances produce a similar result, although somewhat more slowly. A selenium element having an initial resistance of 30,100 ohms falls rapidly to 1,000 ohms under the influence of a feeble diffuse light. On being placed about 1 mm. from a layer of carbonate of barium having the same area, the resistance falls in ten minutes to 29,000 ohms. When the salt is removed, two hours are required for it to rise to its normal value. This result is not due to the phosphorescent glow from the salt, as this was cut off by the interposition of several thicknesses of black paper. It is thought that this fact is in favour of the idea that the radium rays are a mixture of kathode and Röntgen rays. R. S. W.

HEAT.

1495. *Radiation Equation for Polished Platinum.* **D. A. Goldhammer.** (Ann. d. Physik, 4. 4. pp. 828–833, April, 1901.)—In Kirchhoff's equation,

$$\frac{e_\lambda}{a_\lambda} = \varepsilon_\lambda,$$

ε_λ may be shown to be an algebraic function of λ. It follows, therefore, that if the expression for ε_λ contains a transcendental function, then e_λ must also contain the same function.

It is next shown that the formula deduced by Lummer and Pringsheim from their experimental results and which makes the total radiation of platinum nearly proportional to the fifth power of the temperature, can only be looked on as an empirical result and not as expressing a law. According to the same observations $c_{\lambda\lambda}T^{-6}$ seems to remain almost constant. This is here shown to be theoretically impossible.

The formula—

$$c_\lambda = CT^5 \frac{\psi(T)}{(\lambda T)^5} e^{-\frac{c}{\lambda T}}$$

is shown to represent closely the radiation of polished platinum, but this formula and Thiesen's formula,

$$\varepsilon_\lambda = \frac{CT^5}{(\lambda T)^{4\cdot5}} e^{-\frac{c}{\lambda T}}$$

cannot both be correct. Thiesen's formula gives for high temperatures values of ε_λ several per cent. greater than the observed values, and Planck's new formula gives at these temperatures values still greater than Thiesen's.

J. B. H.

1496. *Radiation of Black Bodies.* **H. Rubens** and **F. Kurlbaum.** (Ann. d. Physik, 4. 4. pp. 649–666, April, 1901.)—By means of the residual radiation from quartz the authors are able to extend to shorter wave-lengths (8·85 μ) their test [see Abstract No. 371 (1901)] of the various equations for the distribution of energy in the spectrum. The formulæ of Lummer and Jahnke, and of Planck agree very well with the observations for this region, the latter being simpler but showing small deviations of an apparently systematic character.

W. E. T.

1497. *Generalisation of Trouton's Law.* **de Forcrand.** (Comptes Rendus, 132. pp. 879–882, April 9, 1901.)—Trouton formulated the law that the heat of vapourisation is proportional to the temperature, on the absolute scale, of the boiling-point. The author discusses this law and the additions made to it by Le Chatelier, and finds that the general law can be more correctly expressed thus :—In all physical or chemical phenomena, the heat of solidification of any gas is proportional to the temperature of its boiling-point at atmospheric pressure; or, in symbols, $\frac{L+S}{T} =$ constant, where L = heat of liquefaction of a gas molecule, and S = heat of solidification of this liquid molecule. This

law can only be rigorously verified in the one case of CO_2, as its melting-point, — 78·5° C., is exactly the same as its boiling-point at atmospheric pressure. From the experiments of Favre on the heat required to vaporise a given quantity of solid CO_2, we get for the above ratio 32·1, and 32 is exactly the value given by the dissociable ammoniacal chlorides. For other cases there is a more or less considerable interval between the temperature of solidification and the boiling-point; but as the value of S is always fairly small compared with that of L, we may, no matter what this interval be, use the value of S determined directly at the melting-point, without introducing a large error. The author finds as the mean of the ratios for fourteen different bodies the value 30. W. C. H.

1498. *Latent Heats of Evaporation.* **L. Kahlenberg.** (Journ. Phys. Chem. 5. pp. 215–232, April, 1901.)—A description, with figures, is given of a modification of Berthelot's latent heat apparatus. The boiling of the liquid is brought about by a spiral through which an electric current is passed, by which means superheating of the vapours before passing into the condenser is obviated. By using liquids of known latent heat the apparatus is found to give good results. The following mean values were obtained by it: Pyridine, 104·0; acetonitrile, 173·6; benzonitrile, 87·7; the first two of these numbers differ somewhat from those obtained recently by Louguinine [see Abstract No. 1038 (1900)]. Inserting the above values in the Arrhenius-Beckmann formula, the numbers 28·8, 48·67, and 14·39 are obtained for the boiling-point constants of pyridine, benzonitrile, and acetonitrile respectively. The Trouton-Schiff rule gives, according to Werner, the numbers 29·5, 45·70 and 13·91, while the same author obtained experimentally the values 30·07 and 36·55 for pyridine and benzonitrile respectively. T. H. P.

1499. *Liquefaction of Hydrogen.* **M. W. Travers.** (Phys. Soc., Proc. 17, pp. 561–575; Discussion, pp. 575–576, July, 1901; and Phil. Mag. 1. pp. 411–423. April, 1901.)—An account of the method whereby the author has succeeded in obtaining liquid hydrogen in quantity. The apparatus consists essentially of a modified Hampson air-liquefier. The hydrogen, at a pressure of 200 atmospheres, undergoes a preliminary cooling to —80° C. in solid carbonic acid and alcohol. It is then successively cooled by liquid air boiling under atmospheric pressure, and under a pressure of 100 mm., after which it escapes from the Hampson valve, and being a sufficiently imperfect gas at the low temperature (—200° C.) obtained by the liquid air boiling under low pressure, regenerative cooling is produced, as in the liquefaction of air by the Hampson machine, and liquid hydrogen is obtained. It is collected in a vacuum vessel which is specially insulated from external heat. For further details reference must be made to the original paper which is illustrated by a plate. F. G. D.

1500. *Platinum Thermometry in Cryoscopic Researches.* **P. Chroustchoff.** (Comptes Rendus, 132. pp. 955–957, April 22, 1901.)—The author gives details of the platinum resistance thermometer employed in his cryoscopic researches [see Abstract No. 413 (1901)]. It is a modification of Callendar and Griffiths instrument, from which it differs to some extent in arrangement. The head of the instrument, *i.e.*, the point where the four wires for introducing the current are joined, is made with a strong plate of ebonite covered with a thick layer of paraffin. This perfect insulation of the head of the thermometer is of essential importance if readings of the order of thousandths of a degree are to be made. Moreover, the current from a large accumulator can be kept

constantly passing through the Wheatstone bridge, the galvanometer, which is very sensitive, being introduced into the circuit only at the moment of reading. The three branches of the bridge, two of which are made equal within about the one hundred-thousandth of an ohm, the third having a resistance equal to that of the electric thermometer, are immersed in an insulating hydrocarbon bath. Corrections for the changes of temperature of the third branch of the bridge are eliminated by making blank experiments with the pure solvent used in the cryoscopic determinations. T. H. P.

1501. *Clapeyron's Equation.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 256–258, April, 1901.)—For the thermodynamic potential $\Phi = E - t\eta + pv$ we have $d\Phi = -\eta dt + v dp$, and hence

$$\partial(\Phi,t)/\partial(\eta,v) = v\,\partial(p,t)/\partial(\eta,v).$$

For a univariant system p is a function of t, whence the second Jacobian vanishes, and therefore also the first, so that Φ too is a function of t, and also $d\Phi/dt \equiv -\eta + v\,dp/dt$; we therefore have

$$0 = \partial(-\eta + v\,dp/dt, t)/\partial(\eta,v) = -(\partial t/\partial v)_\eta - (dp/dt)(\partial t/\partial \eta)_v,$$

whence Clapeyron's equation—

$$dp/dt = (\partial \eta/\partial v)_t. \qquad \text{R. E. B.}$$

REFERENCES.

1502. *Isothermals of Ether between* 100° *and* 206°. **E. Mack.** (Comptes Rendus, 132. pp. 952–955, April 22, 1901.)—With apparatus similar to that previously employed for another purpose [see Abstract No. 47 (1899)], the author obtained thirteen isothermals for ether at temperatures beginning at 100·95° and ending at 206·3°. The pressures ranged from 34 to 1,377 kg. per sq. cm. The results, which are tabulated, are in good agreement with the researches of Amagat, and Ramsay, and Young. E. H. B.

1503. *Behaviour of Ether at Constant Volume.* **E. Mack.** (Comptes Rendus, 132. pp. 1035–1037, April 29, 1901.)—The values of the volume of ether given in a previous paper [see preceding Abstract] verify a very simple law discovered by Amagat, namely, that at constant volume the increase of pressure is proportional to the rise of temperature. E. H. B.

1504. *Van der Waals' Equation.* **H. Hilton.** (Phil. Mag. 1. pp. 579–589, May, and 2. pp. 108–118, July, 1901.)—This equation in its reduced form is mathematically discussed as representing a family of curves with θ for parameter, and the corresponding relations, which are of somewhat complex form, between saturation pressures and volumes (the so-called border-curve or connode) and between saturation volumes and temperatures are deduced. R. E. B.

1505. *Entropy of a Gaseous Mixture in Combustion.* **B. Brunhes.** (Journ. de Physique, 10. pp. 325–332, May, 1901.)—Has a gaseous mixture a definite entropy during explosion or combustion? The author discusses this, and shows that under certain well-defined conditions the entropy is definite and calculable. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1506. *Increase of Resistance of Bismuth in a Magnetic Field.* **E. van Everdingen, Jr.** (Archives Néerlandaises, 5. pp. 453–466, 1900.)—The author further inquires into a hypothesis previously made by him, viz., that the number of freely moving charged particles is less in a magnetic field than outside it, pointing out that it leads to a possible explanation of the behaviour of bismuth. He identifies the particles in question with the electrons of Drude's theory, obtaining the value $8{\cdot}7 \times 10^6$ for their mean velocity. He compares the number per c.c. of these electrons in bismuth with the number of atoms, and considers the forces to which an electron is subject, explaining that by "freely moving particles" he does not mean particles unacted on by force; they are subject to the attraction of the positively charged atoms, though the great number of uncharged atoms prevents the electrons from being permanently under the control of this attraction. An electric field gives direction to the passage of the free electrons from the sphere of influence of one charged molecule to that of another, its effect in general on bound electrons being to produce a mere *disturbance* of their motion.

An examination of the influence of the forces due to induction on the excitation of the magnetic field shows it to be negligible. The solution of the equations of motion of an electron in a field of magnetic force parallel to the z axis and electric force parallel to the x axis shows that the motion is of the same form as without the electric force save for the addition of a uniform velocity parallel to the y axis, the path of the electron not being closed but cycloidal; the expression for x contains no term in which the effect of the electric force is progressive; this appears in *cos* or *sin* functions, so that after a complete revolution no displacement has taken place in the x direction; electrons, therefore, which thus move under the influence of a magnetic and electric field take as small a part in the transference of a current as electrons moving in closed paths. However, a calculation of the greatest velocity such electrons could have shows it to be much less than the mean velocity previously determined; but a similar difficulty arises from a comparison of the calculated migration velocity with that derived from the amount of the Hall-effect. Both difficulties are removed by considering that value of the mean velocity as too high, and reasons are given in support of this view. W. E. T.

DISCHARGE AND OSCILLATIONS.

1507. *Ionisation of Atmospheric Air.* **C. T. R. Wilson.** (Roy. Soc., Proc. 68. pp. 151–161, May 4, 1901.)—In his earlier experiments [Abstract No. 1025 (1900)] the author has described the behaviour of positively and negatively charged ions as nuclei on which water vapour may condense; but the question whether free ions are likely to occur under such conditions as would make the results of these experiments applicable to the explanation of atmospheric electricity was then left undecided. The experiments now described were undertaken to determine whether a certain degree of

ionisation might not be a normal property of air. The principal conclusions arrived at from the first set of experiments have already been published [see Abstract No. 849 (1901)], but the present paper contains a full description of the completed experiments and of the special, and very delicate, apparatus used. The method employed was to measure the leakage through dust-free air of electricity from a charged conductor. The difficulty in such experiments is that one is apt to be misled by the leakage due to the insulating support; but the author has managed to eliminate this source of error by fixing his charged conductor to a conducting rod by means of a bead of sulphur, and keeping this conducting rod at a constant potential, equal to the initial potential of the leaking system. Thus any leakage by way of the sulphur bead can only be in such a direction as to cause the leakage through the air to be under-estimated.

In addition to the results already published and given in Abstract No. 849 (1901), the author now gives the results of experiments made on the variation of the rate of leakage with pressure. These show that the leakage is approximately proportional to the pressure; from which we might infer that it should be impossible to detect any leakage through air at really low pressures. This agrees with the observations of Crookes, who showed that in a high vacuum a pair of gold leaves could maintain their charge for months.

Experiments were also made to test whether the production of these ions in dust-free air could be traced to the influence of radiation from sources outside our atmosphere. This test was made by observing the rate of leakage in the ordinary way, and then repeating the experiments in an underground railway tunnel, and comparing the results. If such radiation existed, we should expect it to be absorbed, to some extent at least, by the rocks above the tunnel, thus giving smaller leakage underground. The experiments show no evidence of falling-off of the rate of production of ions when the vessel was underground.

The ionisation thus seems to be a property of the air itself. These ions are continually being produced in atmospheric air to the number of 20 of each kind (positively aud negatively charged) per second in each cubic centimetre.

W. C. H.

1508. *Electric Conduction in Gases.* **A. Garbasso.** (Archives des Sciences, 11. pp. 282–293, March, and 329–344, April, 1901.)—That conduction in gases is electrolytic is not a new idea; the proofs adduced in favour of it have been indirect. The nature of the process should be essentially the same at all pressures, though simpler at low pressures. The author proves that it is easy to show electrolytic phenomena even at atmospheric pressures. Sparks (8 mm.) in a glass globe (4 cm.), the air in which has access to the surface of water, give a shifting glow which shows the spectrum lines of nitrogen only, equally throughout the glow; but if the walls of the globe be damped with an aqueous solution of lithium chloride, the discharge become very bright, mostly localised at the negative pole, and showing lithium only at that pole, while the spectrum of nitrogen comes alone from the positive pole. On reversing the direction of the current, the glows become reversed. Without the presence of some water vapour the phenomenon dies out. If the inside of the globe be damped with an alcoholic solution of LiCl, carbon lines replace N lines round the anode. The spectroscope then fails to reveal the presence of nitrogen. The solvent medium thus plays some important part. In gases, as in liquid electrolytes (Bredig and Haber), hydrogen is occluded

at the surface of platinum electrodes, and may be given out if the electrodes be transferred into another tube ; and the result is more marked with the cathode. The same result is shown with similar apparatus applied to liquid electrolytes. In gases, as in liquid electrolytes (Bredig and Haber), the break-up of the kathodes requires at least (1) a given difference of potential, and (2) a given density of current. Bismuth shows the break-up extremely well ; it is used in thin (1 mm.) rods cast by drawing melted bismuth up into a very thin capillary pipette of heavy glass : as the rod solidifies it expands and bursts its coating of glass. At the instant the rarefaction becomes sufficient to establish a high enough p.d. the bismuth begins to form a mirror on the glass, while at the same moment the production of kathode rays and of fluorescence begins. With kathodes of mercury there is prompt evaporation : mercury lines, very bright, soon completely replace the nitrogen lines ; the transition is slowed down if a diaphragm of earthenware 1 mm. thick be used between the electrodes, and may then take 10 to 15 minutes. If the platinum anode have had hydrogen occluded in it, and be used as a kathode, the hydrogen comes out and hydrogen lines then completely replace the mercury lines. Further experiments are described with discharge passed through cracks in glass. The break-up of kathodes does occur (Bredig and Haber *contrà*) in hydrochloric acid. The work of Wiedemann and Schmidt (Wied. Ann. lxi. 735, 1897) on the electrolysis of HCl gas gives quantitative results at first sight not in accord with Faraday's laws : the chlorine appears to be developed near the anode as well as near the kathode ; but it would seem that the conditions were such that diffusion would account for this. Direct experiment by the authors showed hydrogen lines from round the kathode, chlorine lines from round the anode, with faint hydrogen lines. In ammonia hydrogen lines are shown from round the kathode, nitrogen lines from round the anode, the tendency apparently being for the ammonia and nitrogen to mask the presence of any free hydrogen round the anode. In an ordinary vacuum tube nitrogen does not mask the presence of hydrogen. It is therefore very probable that the conduction of electricity in a gas is electrolytic ; but in any event the process is more complex than is conduction in a liquid electrolyte. A. D.

1509. *Disruptive Discharge in Electrolytes.* **A. Broca** and **Turchini.** (Comptes Rendus, 132. pp. 915–917, April 15, 1901.)—According to Maxwell's theory conductors of electricity should be opaque : while this is true in a large number of cases, electrolytes form a class in which theory and practice are discordant. For electric oscillations of a frequency a little less than a million per second, they may, however, act more like a dielectric than a conductor. An induction coil, capable of giving an arc in air of 5 cm. when driven by a strong alternating current, is joined up with a capacity so as to give a spark without blowing out the arc. A spark-gap is formed of two brass balls about 2 cm. each in diameter ; when this is immersed in oil the appearances are very similar to those obtained in air, but if a liquid conductor is run in in the place of the oil, the sparks gain tremendously in brilliancy, and small bubbles of gas are produced. When the gap is about 2 mm. wide this appearance suddenly becomes less brilliant, but the spark remains disruptive. Unless there is another spark-gap external to the electrolyte this phenomenon cannot be produced. Reasons are given in the original paper for thinking that the discharge in its most active state is disruptive.

The brass spheres forming the break in the circuit are used up much more rapidly than those in the same circuit which are surrounded by air, and this

waste, as well as the brilliancy of the sparks, is still further increased by replacing the spheres by wires. It is a complex phenomenon, and in order further to elucidate it, the *rôle* played by the frequency, the conductivity, the polarisation capacity, and other elements must be investigated. Experiments on these points are now in progress; in the meantime results are given pertaining to a few of the commoner electrolytes. R. S. W.

1510. *Oscillating Sparks.* **G. A. Hemsalech.** (Comptes Rendus, 132. pp. 917–920, April 15, 1901.)—It has already been shown that the irregular form of the spark under ordinary conditions is due to the uneven distribution of the metal vapour from the electrodes [see Abstract No. 2159 (1900)]. By the insertion of a variable self-induction in the discharge circuit it is found that the form of the discharge becomes more and more regular and the initial spark feebler as the self-induction is increased, until it seems to consist entirely of metallic vapour. The regularity or otherwise of the discharge depends largely on the nature of the metallic electrodes; copper and aluminium give the most consistent results. The brilliancy of the spark depends on the last element in a marked manner, and its variation with the induction is different in the various cases. With iron, cobalt, zinc, cadmium, copper, aluminium, and lead, the intensity diminishes at first, then increases and reaches a maximum as the induction is augmented; with other metals it shows no maxima or minima, while for the particular case of magnesium a rapid diminution is observed. That the oscillations are destroyed by the introduction into the self-induction coil of an iron core is very strikingly shown. Photographs of the spark under various conditions are taken by the method described in previous papers (see Phil. Trans. Roy. Soc. t. 193. p. 190, 1899) and some of these are reproduced. The effect is due to the magnetisation of the iron and to Foucault currents, for an iron tube is quite as efficient as a solid core, while a copper tube has an appreciable though a less influence.
R. S. W.

1511. *Periodic Oscillations produced in a Continuous Arc by Alternating Currents.* **E. Koenig.** (Comptes Rendus, 132. pp. 962–963, April 22, 1901.)—A closed circuit transformer of 3 kilowatts was placed on a lighting circuit of 240 volts with a periodicity of 40. The primary coil was of 308 turns; the secondary in five sections of 17 turns each, each section giving 13 volts. In a continuous-current circuit of 120 volts was placed a resistance coil, a hand-regulated arc lamp, and a section of the transformer secondary, all in series. Directly the alternate current was sent through the primary of the transformer the light of the arc, up to then stable, showed luminous periodic oscillations, slow enough to be perceptible to the eye. When the arc was lengthened a feeble sound corresponding to 40 oscillations per second was heard; the period of the luminous oscillations was only about $\frac{1}{20}$ of a second as estimated stroboscopically. On increasing the strength of the alternating current the luminous oscillations became more marked, without, however, altering in frequency. E. C. R.

1512. *Striated Electrical Discharge.* **J. H. Jeans.** (Phil. Mag. 1. pp. 521–529, May, 1901.)—This paper forms a continuation of a former one by the same author [see Abstract No. 1069 (1900)] and deals with one of the assumptions made in that paper, investigating as to how far the results obtained will remain valid if the assumption is not complied with. J. B. H.

1513. *Absorption of Gas in a Crookes Tube.* **R. S. Willows.** (Phil. Mag. 1. pp. 503–517, April, 1901.)—The author here describes experiments undertaken to investigate the rate of absorption of gas in a Crookes tube, and the influences exerted by the nature of the gas, the size, shape, and material of the electrodes and the composition of the glass. To give some idea of the magnitude of the effects one experiment may be instanced. With a volume of 108 c.c. and a pressure of 1 mm., a current of $10{\cdot}8 \times 10^{-4}$ amperes passing for 30 minutes reduced the pressure nearly one-eleventh.

It appears from the experiments that most, if not all, of the gas absorbed, is to be accounted for by a chemical combination with the glass ; that if tubes are desired in which the pressure remains constant they should be made of Jena-glass in preference to lead-glass, and of lead-glass rather than soda-glass ; and finally, that in the first two cases hydrogen is absorbed to a far less extent than air or nitrogen, the last two gases showing little difference.

J. B. H.

1514. *Radiation produced by the Impact of Slowly Moving Kathode Rays.* **J. J. Thomson.** (Phil. Mag. 1. pp. 361–376, April, 1901.)—One end of a tube is made of a brass plate A, perforated with five holes placed near together ; the holes are covered on the outside with very thin aluminium foil. The face of the plate inside the tube is covered with a mica disc with a hole cut in the middle to allow the electric discharge from another electrode B to have access to A. On the outside of the plate A is a metal tube containing an insulated electrode C connected to an electrometer. The metal tube and plate A are kept to earth and a discharge allowed to pass between A and B. It is then found when the discharge passes between A and B that under certain circumstances electricity leaks from C. This leakage is greater when the plate A is kathode, but this may be because the potential difference between the electrodes of the discharge tube is less than when the current is passing in the opposite direction. The rate at which C leaks is independent of the sign of its electrification, and it does not receive a charge if it is uncharged at the beginning. This shows that the gas surrounding C is ionised, and that the ionisation is similar to that produced by Röntgen rays. If the leaking disc is replaced by a photographic plate, photographs of the holes are obtained after a few minutes' exposure. There is thus outside the tube, even when the gas is at a pressure very much greater than that in ordinary Röntgen tubes, a radiation which possesses properties similar to Röntgen radiation. This radiation is produced by the discharge from an induction coil, but more regularly by the discharge from a battery. Its chief characteristic is the ease with which it is absorbed by thin layers of aluminium or air. Its origin is found to be where the negative glow hits against a solid surface, thus when the window A is kathode and the negative glow extends to the anode B, the latter is the source of the rays. If the negative glow is deflected from B by a magnetic field then the leakage from C ceases ; if the tube is exhausted so that the dark space extends to B then the leakage is very small. Other tubes can be made in which the window is not an electrode, and it is then proved that the radiation producing the leakage does not come from the light of the luminous negative column. By putting the tube containing the testing disc C in between the electrodes of the discharge tube and using a movable kathode, the way in which the leakage varies with the distance from the latter can be found. The result shows that there is a rapid increase up to the junction of the dark space with the negative glow, after which there is a gradual falling off as the kathode is further removed.

The second part of the paper gives a detailed explanation, from a mathematical point of view, of the phenomena in vacuum tubes. It has been advanced by the author that the chief agent in producing ionisation is the stream of rapidly moving negative ions, and this view has been strengthened by experiments of Townsend. These ions are removed from the gas by colliding with molecules and adhering thereto. On these two suppositions as foundation, a differential equation is found, giving the electric force at different portions of the tube ; and although this cannot be solved, yet there can be inferred from it the general distribution of the force, and this is found to agree with the experimental results of Skinner and Wilson. R. S. W.

1515. *Coherer Working.* **K. E. Guthe.** (Ann. der Physik, **4.** 4. pp. 762–775, April, 1901.)—Examination is made of the (*a*) negative coherer action associated with the name of Bose, (*b*) the critical potential difference for various metals, by which he implies the lowest voltage which will enable a coherer to act, (*c*) resistance variations in the coherer, (*d*) effect of heating the contact points.

The work embraced under (*b*) is new and is confirmed by many observations given in this paper. For common metals its value is from 0·2 volt to 0·06 volt. P. E. S.

1516. *Action of a Coherer.* **K. E. Guthe.** (Phys. Rev. **12.** pp. 245–253, April, 1901.)—Guthe and Trowbridge have shown [see Abstract No. 2209 (1900)] that in a coherer there is a certain maximum voltage, called the *critical voltage.* The author now finds (1) on trying many metals, that the product of critical voltage into atomic weight is a constant, in each of several groups ; (2) that true *metallic* contact exists in the cases tried, although he looked for electrolytic contact ; (3) the higher the temperature of the contact, the lower the resistance of the coherer—and the resistance rises again to the normal when the current (which causes the heating) ceases. P. E. S.

1517. *Double Refraction of Electric Waves.* **G. Pierce.** (Phil. Mag. **1.** pp. 548–551, May, 1901.)—A former communication [see Phil. Mag., Feb., 1901 ; and Abstract No. 1105 (1901)] described experiments on measurement of refractive indices for electric waves of several doubly refractive media, viz., various woods. These media were also doubly absorptive. In the present paper the question is examined as to whether, on Maxwell's theory, the double absorption is sufficient to account for the double refraction, and, indeed, whether both these properties can be ascribed merely to differences of conductivity of the woods along and across the grain. The mathematical treatment adopted is that used by Boltzmann in "Vorlesungen über Maxwell's Theorie," § 96 (Leipzig, 1891), though with different application. An equation is found connecting velocity and absorption of the waves in a given weakly-conducting dielectric. The medium is not supposed to be crystalline in the sense of having different dielectric constants along different axes, but merely heterogeneous in that it has different conductivities along different axes. The equation shows that in that orientation of electric force in which absorption is greatest, velocity is least, and therefore index of refraction greatest. This agrees with the results of the experiments on woods. In all the specimens tested, both index and absorption were found to be greater when the grain was parallel to the electric displacement than when it was perpendicular. The writer had not sufficient data at disposal to test the question as to whether the assumption of heterogeneous conductivity suffices

to entirely explain the double refraction of electric waves by wood, though he suggests a way in which this might be done. But he draws the conclusion that heterogeneous conductivity plays an important part in the phenomenon. A. E.

1518. *Measurement of the Period of the Waves used in Wireless Telegraphy.* **C. Tissot.** (Comptes Rendus, 132. pp. 763-766, March 25, 1901.)—The method adopted was that of Feddersen, a method which has been carried to a high degree of perfection in the recent experiments of Décombe. The image of the spark is received on a rapidly rotating concave mirror, and is sent back upon a photographic plate, where it is split up and fixed. Various modifications of Décombe's arrangement have been introduced. At first the results obtained did not lend themselves to exact measurement, and scarcely indicated the oscillatory nature of the discharge, but on interposing in front of the turning mirror and on the path of the incident beam a cylindrical lens of great focal length, a great improvement was noticed, and a series of equidistant fringes of decreasing intensity was obtained on the plate. These were very distinct, and it was possible to measure their width. The indications obtained showed that the period was single and remained invariable for a given length of the antenna and the same length of spark. This period varies not only with the length of the antenna, but also with the length of spark. The periods measured were (to a first approximation) between $0{\cdot}6 \times 10^{-6}$ second and $1{\cdot}8 \times 10^{-6}$ second. The damping is shown by the decrease of the intensity and of the length of the images. The damping is always very marked, so that sometimes only three or four images at the most can be distinctly observed. J. J. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1519. *Measurements of v.* **H. Abraham.** (International Physical Congress at Paris, Report, 2. pp. 247–267, 1900.)—An account is given of some of the most important experimental methods recently employed for the determination of the number v, the ratio between the electromagnetic and the electrostatic unit of quantity of electricity. The mean of the seven measurements which are considered the most accurate is—

$$v = 3{\cdot}0001 \times 10^{10}.$$

J. J. S.

1520. *Hall-Effect in Flames.* **E. Marx.** (Phys. Zeitschr. 2. pp. 412–413; Discussion, pp. 413–414, April 6, 1901. Paper read before the 72nd Naturforscherversammlung at Aachen.)—Let $\frac{\pi}{x}$ = primary potential gradient; H = strength of magnetic field; $\frac{e}{z}$ = potential gradient of Hall-effect; u, v = mobilities of positive and negative ions; theoretical investigations have shown that these quantities are connected by the relation—

$$\frac{e}{z} \Big/ \frac{\pi}{x} = \frac{u-v}{2} \cdot \mathrm{H}.$$

This formula cannot be tested by means of aqueous solutions owing to the extreme smallness of the Hall-effect in this case. In gases, too, owing to our ignorance of the way in which u and v depend on the potential gradient, a

quantitative test is only feasible for very small gradients, in which case the Hall-effect again becomes too small to be accurately measured. These difficulties have been surmounted by the author by experimenting with the glowing gases in flames, because in this case, owing to the high temperature and consequent large internal friction, direct proportionality between ionic velocity and gradient can be legitimately expected as far as 100 volts per centimetre. Moreover, by spraying salt solutions into the flame, the effects for many different salts can be determined. For experimental details the author refers to a previour paper [Abstract No. 2211 (1900)]. The experimental results show that the quantity $\frac{c}{z}\Big/\frac{\pi}{x}$ H is independent of variations in the strength of the magnetic field, potential gradient, and distance between the electrodes, as predicted by the convective theory.

The results also indicate that the velocity of the positive carrier in the unsprayed flame is considerably smaller than that of the positive ion in flames coloured by the salts of the alkaline metals.

In comparing $\frac{c}{z}\Big/\frac{\pi}{x}$ with $\frac{u-v}{2}$ H, a correction has to be introduced owing to the acceleration of the ions. This correction is very difficult to make, and can only be applied by employing very small primary gradients and very delicate measuring instruments. When the correction is made, it is found that there is agreement so far as order of magnitude is concerned.

The paper is followed by a discussion between Quincke and Marx, which does not appear to have brought out any new or important point. F. G. D.

1521. *Electrocapillarity of Organic Compounds in Aqueous Solution.* **Gouy.** (Comptes Rendus, 132. pp. 822–824, April 1, 1901.)—The compounds examined by the author are methyl, ethyl, propyl, allyl and amyl alcohols, aldehyde, acetone, glycerine, erythrite, glucose, saccharose, lactose, phenol, pyrogallol, resorcinol, hydroquinone, acetamide, asparagine, caffeine and amygdaline, the strengths of the solutions varying from a gramme-molecule per litre to the one-thousandth of that value. To study the electrocapillarity curve throughout its whole extent it is necessary to use as solvent a dilute solution of an electrolyte, that used by the author being a centinormal sodium sulphate solution. A table is given containing for the compounds named above the values of δ, or 1,000 (H — H′)/H, where H is the maximum height of the column of the capillary electrometer of the sodium sulphate solution, and H′ the maximum height after the addition of the organic compound. It has already been found that δ is independent of the actual electrolyte employed, provided that it is in dilute solution, is inactive by itself and has no chemical action on the substance examined. The results show that some organic compounds, which conduct only slightly or not at all, produce quite appreciable electrocapillary effects which are often more considerable than those of the most active electrolytes. In some cases, more especially with very dilute solutions of extremely active bodies, such as caffeine and amygdaline are found to be, electrocapillary viscosity is exhibited, that is, the value of H′ diminishes to a final value. The new physico-chemical constant δ has very different values for different compounds, even for isomerides, and the way in which it varies with the dilution is very characteristic. T. H. P.

1522. *Electric Conductivity of thin Metallic Films.* **J. J. Thomson.** (Cambridge Phil. Soc., Proc. 11. pp. 120–122, April 22, 1901.)—In the

electronic theory of electric conduction in metals the conductivity is expressed in terms of the mean free path of the electron. The mean free path calculated for bismuth is of the order 10^{-4} or 10^{-5} cm., so it is possible to obtain metallic films of less thickness than the mean free path in an unlimited mass of metal. The expression for the mean free path in a film of thickness d is—

$$\lambda' = d\left\{\tfrac{3}{4} + \tfrac{1}{2}\log\frac{\lambda}{d}\right\},$$

where λ is the mean free path in the unlimited mass. The specific resistance ought therefore to be a function of the thickness of the film. Experiments show that the electrical properties of thin films are qualitatively in accordance with the theory, but further experiments are needed before anything can be said as to the numerical agreement. J. B. H.

1523. *Influence of Wave-form on Ammeters and Voltmeters.* **G. Benischke.** (Elektrotechn. Zeitschr. 22. pp. 301–302, April 4, 1901.)—The author has investigated the effect of three different wave-forms, a sine curve, a very flat curve, and a very peaked curve, on induction and electromagnetic ammeters and voltmeters, of the Allgemeine Elektrizitäts-Gesellschaft's type. The induction instruments show no difference at all in their readings on different wave-forms. The electromagnetic, on the contrary, show considerable variations, amounting to 10 per cent. difference in the readings on a flat and on a peaked curve, the former giving the higher readings. The calibration curves of the instruments are given in the paper, and are in every case straight lines, that for the sine curve lying between the other two. G. H. B.

1524. *Apparent Resistance of d'Arsonval Ballistic Galvanometer.* **D. Robertson.** (Electrician, 46. pp. 901–904, April 5; and 47. pp. 17–20, April 26, 1901.)—When a d'Arsonval galvanometer used ballistically with a search coil, the motion of the galvanometer coil in its field generates an e.m.f. which is in opposition to the e.m.f. producing the throw; this has the effect of an additional resistance in the galvanometer circuit, and entails a correction, if the galvanometer constant be found from a condenser discharge, or from the steady current constant, or if found from a standard field with a different resistance in circuit to that with which the galvanometer is used. If G be the galvanometer resistance, R + G the total resistance in circuit, k the galvanometer constant, q the product of the numbers of turns in the coil into the change in lines produced by unit deflection, and of d, the deflection produced by a change of N lines in the search coil of n turns. Then—

$$Rd = Nn/k - (G + q/k)d.$$

Here q/k is the correction due to the motion of the galvanometer coil, which has the effect of giving the galvanometer an apparent resistance $= G + q/k$.

The author plots curves between Rd and d, for different galvanometers, the curves being slightly concave towards the origin by reason of the variation of the term q/k. When the search coil is shunted, the correction due to the damping effect of the shunt takes a similar form; if s be the shunt resistance—

$$Rd = Nn/k - (G + q/k)\frac{R + s}{s}d.$$

The author gives a table containing particulars of the three galvanometers; their apparent resistances, and their constants are calculated by a condenser, a standard coil, and by the steady current method. The constants given by the

standard coil are from 6 per cent. to 10 per cent. higher than those given by the other methods.

The author also treats mathematically the damping effect of a shunt when used with a condenser and galvanometer, and gives curves, showing the results of his experiments with shunts of different resistances. G. H. B.

1525. *d'Arsonval Galvanometer Independent of the Field.* **P. Weiss.** (Comptes Rendus, 132. pp. 957–959, April 22, 1901.)—The author attaches to the coil of an ordinary d'Arsonval type galvanometer or ammeter a small soft-iron needle, and suspends the coil with wires exercising as little directive force on the coil as possible. The directing force is then due to the action of the permanent magnet on the iron needle, and as the deviating force also depends on the same magnetic field, the deflections are independent of any variations in the strength of the magnet. That this is so is evident from a table giving the currents required to produce deflections up to 70° with fields of 500 and of 600 gauss; the maximum difference is only $\frac{1}{2}$ of 1 per cent. The deflections, however, are not exactly proportional to the current. G. H. B.

1526. *Standard Cells.* **W. Jaeger** and **S. Lindeck.** (Zeitschr. Instrumentenk. 21. pp. 33–49, Feb., and 65–80, March, 1901. Communicated by the Phys. Tech. Reichsanstalt.)—These papers contain a description of tests carried out in the Reichsanstalt on Clark and Cadmium cells, with special reference to the constancy and reliability of the Weston Cadmium cell.

The papers are divided into four sections as follows :—

1. Preparation of Cadmium cells (with 13 per cent. amalgam), and of Clark cells in 1899, and their comparison with older cells in the same year.

2. Repetition of these measurements in 1900 also extended to a temperature interval from 0° to 30° C.

3. Preparation of Cadmium cells (with 13 per cent. and 12 per cent. amalgams) at the end of 1900, and their comparison at 0° and at ordinary temperatures.

4. Summary of results and criticism of Cohen's investigations.

The comparison is summarised in the following table :—

Nr.	Time.	Wt. of Observation.	Clark 0° / Cadmium 20°.	Clark 15°. / Cadmium 20°.	Clark 0°–Clark 15°. Volt.	Observer.
1	Mar., 1896	1	1·4227	1·4066	0·0164	Jaeger, Wachsmuth
2	Jan., 1897	2	1·42277	1·40676	0·01631	,, Kahle
3	Nov., 1897	3	1·42280	1·40660	0·01650	,, ,,
4	Oct., 1899	3	1·42283	1·40679	0·01634	Lindeck
5	Dec., 1900	3	1·42282	1·406675	0·01645	Jaeger, Lindeck
	Mean		1·42280	1·40669	0·01641	
	Former Mean (1–3)		1·42277	1·40665	0·01642	

The previously determined temperature formulæ for the Clark cell and for the Weston Cadmium cell (with 14·3 per cent. amalgam and saturated solution) are found to hold as completely as could possibly be expected. The Cadmium cell with 14·3 per cent. amalgams, which show great deviations from the normal when cooled to about 0° C., may be used as standard cells above 10° C. Cadmium cells with 12 and 13 per cent. amalgams show no irregularities even when kept for a week at 0° C. Weston Cadmium cells are pre-eminently suited for standard cells. J. B. H.

1527. *New Phonographic Principle.* **W. Nernst** and **R. v. Lieben.** (Zeitschr. Elektrochem. 7. pp. 533–538, April 4, 1901.)—Sound is received on a microphone ; the currents there set up are passed through a transformer to an endless platinum band run by a motor from one drum to another. The currents enter the band on touching one drum and leave it where it touches a wooden wedge soaked in some electrolyte ; the currents then pass through the electrolyte in a vessel and leave by the other, metal, electrode. Thus the circuit is completed.

If the platinum is run fast enough, alternating polarisation will be set up on its surface. If, when this has been done, we remove the microphone and connect the system to a telephone, then we shall obtain a reproduction of the original sounds. The principle was found to be successful.

In a paper immediately following the above, **R. v. Lieben** follows up the principle by various improvements, notably that the platinum band is replaced by a strong copper disc, it having been found that the former was frequently broken in working. P. E. S.

1528. *Practical Magnetic Measurement.* **J. A. Montpellier** and **M. Aliamet.** (Électricien, 21. pp. 146–147, March 9 ; 177–179, March 23 ; 209–210, April 6 ; 225–228, April 13 ; 244–250, April 20 ; 305–307, May 18 ; 321–322, May 25 ; and 342–345, June 1, 1901.)—Magnetic measurements in practice are confined to the determination of permeability and hysteresis. For dynamo field magnets a knowledge of the permeability only is required ; for transformer iron only the hysteresis is important ; while for dynamo armatures both quantities should be known. The authors give the following figures as standards for iron of good quality : The ampere-turns per cm. to give 8,000 gauss, should be, in cast-iron, 60 ; in wrought-iron, 2 ; and in cast-steel, 1·96 ; in the two latter, 15 ampere-turns per cm. should give 15,000 gauss. As regards hysteresis, the coefficient η, should be, if possible, below 0·0016, and never above 0·002.

The methods of measuring permeability may be divided into four classes : (1) By the ballistic galvanometer ; this is not suitable for industrial use. (2) By measuring the pull. Under this head the authors describe Carpentier's permeameter, Du Bois' magnetic balance [Abstract No. 1686 (1900)], and Fischer-Hinnen's balance. The last-mentioned balance has a massive four-sided iron yoke, divided into a lower fixed part and an upper movable part ; on one side the magnetic circuit is completed by the test-rod, 80 mm. high and 500 sq. mm. in section, which is surrounded by the magnetising coil. The upper part of the yoke is supported on knife-edges projecting from the other vertical limb, the upper part being separated from the lower by a circular air-gap, the centre of which is the line of the knife-edges. A graduated bar projects horizontally from the upper part of the yoke, and carries a sliding weight which counterbalances the pull exercised by the test-rod. The balance is calibrated by placing weights on a scale pan hung in a vertical line with the centre of the test-rod, and noting the position of the sliding weight to give balance, the positions corresponding to values of the induction given by the formula $B = 5{,}000\sqrt{\frac{F}{S}}$, where F is the weight in kilos, and S is the section in sq. cm. In taking a measurement the sliding weight is set to the induction required, current is passed through the magnetising coil sufficient to hold the yoke down, without any weights in the pan, and is then gradually diminished till the yoke is lifted ; the current at this moment, multiplied by a constant, gives the value of H. This is subject

to a correction at low inductions for the reluctance of the yoke and air-gap. (3) Methods by measurement of the magnetic field. Under this head are described Hartmann and Braun's permeameter, in which the field is measured by the resistance of a bismuth spiral, Siemens and Halske's permeameter [Abstracts Nos. 662 and 663 (1898)], and Carpentier's torsion permeameter [Abstract No. 522 (1901)]. (4) Comparison methods, in which the permeability of the test-rod is compared with that of a standard rod of similar dimensions. As instruments of this class, the authors describe Ewing's bridge and Holden's bridge. The latter is similar to Ewing's with the difference that, whereas in Ewing's bridge balance is obtained by varying the turns of the magnetising coil on the test-rod, in Holden's it is obtained by varying the current. Balance is indicated in the same way by a magnetic needle, but in Holden's instrument this is acted on by the leakage field only, not by pole-pieces in a magnetic shunt, as in Ewing's. The current is measured by a Weston voltmeter, which can be connected by a switch to either of two resistances, one in the circuit of each magnetising coil. Commutators are provided to reverse the direction of the magnetising currents; this should be done several times after each change of current to avoid errors due to hysteresis.

Coming to hysteresis measurements, these are divided into two classes: indirect, by tracing the hysteresis curve; and direct, by measuring the energy wasted. Under the first head, the authors describe the step-by-step method of tracing the hysteresis curve, and Ewing's curve tracer; under the second head they describe the method by a wattmeter, and, very fully, Ewing's hysteresis meter, and finally the Blondel-Carpentier meter. G. H. B.

1529. *Theory of Induction Coils.* **K. R. Johnson.** (Ann. d. Physik, 3. 3. pp. 438–460, 1900; and 4. 1. pp. 137–164, Jan., 1901.)—*Part I.*—The author refers to the work of Colley, Oberbeck and Walter as giving the present state of the theory of the induction coil. Several particulars are instanced where experiment does not support theory, and it is pointed out that the theory has serious limitations by quite neglecting the change which the e.m.f. suddenly undergoes at a spark discharge. Starting from the fundamental equation

$$E_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} + R_1 i_1,$$

for the primary, a small gap is assumed to be present in the secondary circuit for which the following equation is given :—

$$L_2 \frac{di_2}{dt} + M \frac{di_1}{dt} + R_2 i_2 = 0.$$

From these, and the equations for the currents i_1 and i_2 in primary and secondary, solutions are found for the e.m.f.'s E_1 and E_2. From an expression for E_1 it is shown that the best capacity for the primary circuit is the smallest that will prevent the spark at break. This has been verified experimentally by Walter and Mizuno. From the solution for E_2 an expression is developed for the time interval between the nth and $(n+1)$th elementary sparks, viz. :—

$$\tau_n = \frac{C_2 (E_0 - V_0) \epsilon^{\gamma l_n} - f(l_n, \tau_n)}{B_0 \gamma}$$

where C_2 is the capacity of the secondary, B_0 and γ constants, $E_0 - V_0$ the fall of the potential at spark, and l_n the time from the first spark. If the

periodic member $f(t_n, \tau_n)$ be negligible, this equation furnishes a theoretical deduction of the law established experimentally by Moll, that the time intervals between successive elementary sparks increase in geometrical progression. As Moll's paper supports the author's theory a considerable extract is given. The above equation is reduced to the form—

$$\tau_n = \frac{L_2C_2(E_0 - V_0)}{Mi_0} \cdot \epsilon^{\gamma t_n} \times \text{a fraction nearly equal to unity,}$$

where L_2 and M are the induction coefficients of the secondary, and i_0 the current in the primary. Neglecting the fraction, the quantity—

$$\frac{L_2C_2(E_0 - V_0)}{Mi_0}$$

is the constant κ of Moll's equation $\tau_n = \kappa\epsilon^{\gamma t_n}$, and calculations are made from Moll's tables to show that when i_0 varies, κi_0 is constant. Taking λ as the spark length, and the relation of λ to spark potential as given by—

$$E_0 - V_0 = a + b\lambda,$$

Moll's numbers are again used to show that—

$$\frac{d\kappa}{d\lambda}\left(= \frac{L_2C_2}{Mi_0} \cdot b\right)$$

is constant for sparks from 0·5 to 2·5 mm. in length.

Part II.—The consideration of the current induced at make, or first induced current, leads to an expression for the e.m.f. in the secondary circuit at time t. This is used in showing that the time integrals of the induced currents at make and at break are numerically equal. It is further shown that the integral $\int_0^\infty i^2 dt$ is numerically larger for the second induced current than for the first. These results agree with experiment, viz., that a galvanometer needle gives equal throws for the two induced currents, but a dynamometer in the secondary circuit gives a greater throw for the second induced current than for the first. The latter and larger part of the paper has reference to the conditions under which spark discharge takes place. The maximum tension in the secondary must be the same for both induced currents, and the greater sparking power of the second current is due to the quicker passage of that current. By taking the maximum length of spark as proportional to the sparking potential, and to the amplitude and frequency of the current, an equation is formed, a similar one being found by substituting amplitude of e.m.f. for that of the current. Either of these equations might represent the true conditions, but two tables of experimental data taken from Moll's paper (1886) would seem to verify the first of these equations.

The secondary circuit is next altered by placing a condenser in parallel with the spark-gap, and the equations of motion are set down. As the general solution depends on an auxiliary equation of the fourth degree, single cases only are considered. It is thus found that the greater the self-induction of the spark-gap the smaller will be the potential variations produced by the current feeding the gap. This has been confirmed by Hemsalech. From the second case considered it is concluded that the local oscillations set up by the branching of the conductors are quite considerable compared with the oscillations of the main secondary current. Since the capacity and inductance of the wires are so small, the frequency is so large as to be able to cause a continuous spark resembling a silent discharge. Extracts from Moll's paper

are reproduced in support of this. By giving the spark-gap a resistance value and assuming the sparks regular, the duration of the silent discharge is expressed, and in an appendix some values are calculated for duration and e.m.f. of discharge and resistance of gap. Although these vary within wide limits, they are considered by the author to confirm the assumption that the silent discharge does not consist of a continuous current, but of a series of elementary sparks which follow so closely on one another that they cannot be separated by a rotating mirror. Some results of Arrhenius also appear to add confirmation. G. E. A.

1530. *Compensating Voltmeters for the Voltage Drop in Long Feeders.* **M. B. Field.** (Inst. Elect. Engin., Journ. 30. pp. 567–591 ; Discussion, pp. 591–595, April, 1901.)—The author describes various methods of compensating a station voltmeter so that it will indicate the actual voltage at the various feeding-points of a two-wire network. He shows also how the voltmeter can be made to indicate the average pressure at all the feeding-points or at any desired group of feeding-points. If a multiple contact voltmeter switch is provided, then the same instrument can be used to read both the individual and the average voltages. The method involves inserting a resistance in each feeder circuit and having resistances between the bus-bars. At the maximum current the drop across the resistance in the feeder-circuit should be about two-tenths of a volt. A method is given of measuring by means of a low-tension electrostatic voltmeter the pressure at the far end of a long alternating current power-transmission line. A large and a small condenser are put in series between the mains, and the voltmeter is joined between their connecting wire and a point on a main at some distance from the station. Proofs are given of the formulæ.

In the discussion, **W. McWhirter** pointed out drawbacks to the use of Weston moving-coil meters. In his reply the author stated that any type of sensitive instrument could be used with his methods. A. R.

ALTERNATING CURRENTS AND MAGNETISM.

1531. *Method of obtaining Alternating Currents and Voltages in the Same Phase.* **A. Campbell.** (Abstract in Phys. Soc., Proc. 17. pp. 608–609, July, 1901 ; and Electrician, 46. p. 506, Jan. 25, 1901.)—The method is designed to produce fictitious non-inductive loads for testing energy or power meters. In the circuit containing the series coil of the instrument is a non-inductive resistance, shunted by the primary of a transformer. The secondary of the transformer is connected with the pressure coil of the instrument, and gives current in phase with the series-coil current. G. H. B.

1532. *Resonance with Alternating Currents.* **A. Russell.** (Inst. Elect. Engin., Journ. 30. pp. 596–606, April, 1901.)—It is known that if the current and e.m.f. curves are simple sine functions of the time that the power-factor is unity when there is electrical resonance. The author examines cases in which the curves are not simple sine functions, and arrives at the following conclusions :—

(1) The power-factor of a resonant circuit can only be unity when the applied potential difference wave is sine-shaped.

(2) The rise of pressure in a resonant circuit depends on the shape of the current wave. If the ohmic resistance of a choking coil, in series with a condenser, is negligible, the maximum pressure across the condenser is

infinite for a sine wave, 9·22 times the applied pressure for a parabolic wave, and 2·45 times the applied pressure for a triangular wave.

(3) If the inductance of the choking coil is varied, then the pressure across the condenser terminals is a maximum when $CL(\beta n)^2$ is unity, where C is the capacity, L the inductance, n the frequency, and β is a constant depending on the shape of the current wave. The minimum value of β is 2π, when the wave is sine-shaped.

(4) If the choking coil is in parallel with a variable condenser, then the current in the main is a minimum when $CL(\alpha n)^2$ is unity, where α is a constant depending on the shape of the potential difference wave. When this wave is sine-shaped, α has a minimum value of 2π.

(5) A condenser and choking coil whose magnitudes are connected by the relation

$$CL(2\pi n)^2 = 1$$

can be used as follows to test how much the applied potential difference wave varies from the sine shape :—

Connect them in parallel and let the current in the main be C, in the condenser C_1, and in the choking coil C_2. Then the smaller the ratio of C to either C_1 or C_2, the more nearly does the form of the wave approach the sine shape.

(6) If the condenser and choking coil be connected in series, and if $CL(2\pi n)^2$ equals unity, then if the voltage, V_2, across the choking coil equals the voltage, V_1, across the condenser, the current wave is sine-shaped. The greater the ratio of V_2 to V_1, the more distorted will be the current wave.

W. G. R.

1533. *Measuring Induction in a Yoke.* **Z. Crook.** (Amer. Journ. Sci. 11. pp. 365–368, May, 1901.)—A slot is made of $\frac{1}{4}$ mm. width in the yoke of a bar-and-yoke apparatus. Then by suddenly pulling out a fine coil in the slot connected to a galvanometer, a measure can be obtained of the induction in the yoke. Next ascertain by experiment the leakage flux for the yoke, and correcting for this, find the induction in the bar whose permeability is required. By this method the bar need not be divided, as in the usual method. P. E. S.

1534. *Magnetic Properties of Cast Iron containing Aluminium.* **A. Schweitzer.** (Elektrotechn. Zeitschr. 22. p. 363, April 25, 1901.)—Four specimens, containing from 0 to 2·45 per cent. aluminium, were tested. The latter percentage (with H = 20) reduced B from 4,420 to 2,170, and (with H = 60) from 8,000 to 5,230. The hysteresis loss, in ergs per c.c. per cycle, was increased from 1,990 to 2,800 with B = 2,000, and from 12,950 to 25,370 with B = 6,000. The results are tabulated and plotted. W. H. E.

1535. *Theory of Magnetic Induction.* **J. Buchanan.** (Phil. Mag. 1. pp. 330–341, March, 1901.)—Solutions of an equation of the same form as Fourier's equation—

$$\frac{dv}{dt} = k\frac{d^2v}{dx^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

are capable of expressing the complex results of magnetic experiments. Functions which are solutions of (1) are not only capable of satisfying the terminal conditions, but also of expressing the complex relationship of I and

H, even when affected by strain, temperature, &c. Begin by assuming an equation—

$$\frac{dI}{dH} = p\frac{d^2I}{d\theta^2}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where p is a constant and θ a quantity whose numerical value is altered by strain, change of temperature, &c. By substituting $x = \theta p^{-\frac{1}{2}}$—

$$\frac{dI}{dH} = \frac{d^2I}{dx^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

and a solution of (3) is found periodic in H. Graphs of a function derived from this solution are found to resemble magnetic curves when a suitable choice of constants is made. The closed curve may be represented by periodic functions of a continuously increasing variable if it be looked on as a single continuous curve folded back on itself.

Examples and curves are given in which various values are taken for the different constants. The author hopes that fuller investigation may lead to a more intimate knowledge of the numerical values of x, the function of the molecular condition of materials. It is possible that the numerical value of x may prove to be as much a property of the material as, for instance, its specific heat. In the case of cyclic stress in magnetic fields of great intensity, the graph reduces more and more nearly to a simple cosine curve, which is in agreement with experimental facts. G. E. A.

1536. *Effect of Magnetic Field on Resistance of thin Metallic Films.* **J. Patterson.** (Cambridge Phil. Soc., Proc. 11. pp. 118–119, April 22, 1901.)—Longden has shown that the resistance of thin metallic films, deposited on glass by means of the kathode discharge, is much greater than that calculated from the ordinary specific resistance of the metal [Abstract No. 2214 (1900)]. The author now tries the effect of a magnetic field upon the resistance of such films. Using bismuth films, of thicknesses 1×10^{-5} cm., 6×10^{-6} cm., and 4×10^{-6} cm., and fields of 26,200 and 27,500 lines per sq. cm., he finds that the change of resistance in the magnetic field is a small increase (0·27 per cent. for the thickest film, 0·01 per cent. for the thinnest), but a very much smaller increase than that of bismuth in the form of wire. The change of resistance decreases with decrease in the thickness of the film. A film of cobalt, 1·4 × 1·3 cm. and resistance 682·2 ohms, gave no change of resistance in a field of 27,500 lines per sq. cm. W. C. H.

1537. *Magnetic Properties of an Alloy of Iron and Aluminium.* **S. W. Richardson** and **S. C. Laws.** (Phil. Mag. 1. pp. 296–301, March, 1901.)—The permeability of an alloy of iron and aluminium containing 2·42 per cent. of aluminium is found to vary in a very complex manner with temperature so long as the alloy is unannealed. The curve, expressing the induction as a function of the temperature for a constant field, has three maxima between 0° and 800° C. As the alloy is repeatedly heated and cooled these maxima gradually disappear, and when properly annealed only one maximum ordinate exists. The induction also increases at all temperatures as the annealing improves. J. B. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1538. *Formation of Kainite.* **J. H. van't Hoff** and **W. Meyerhöffer** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 19. pp. 420–427, April 11, 1901.)—This is a continuation of a series of papers on the Stassfurt salt deposits [see Abstracts Nos. 528 and 665 (1901)]. Kainite, $MgSO_4 . KCl . 3H_2O$, is formed at 25° from solutions saturated with magnesium sulphate and potassium chloride. The conditions of its existence in the presence of various saline mixtures have been determined and are represented diagrammatically. N. L.

1539. *Vapour-Pressure of Binary Mixtures.* **P. Duhem.** (Zeitschr. Phys. Chem. 36. pp. 605–606, April 2, 1901.)—Kohnstamm's claim [see Abstract No. 936 (1901)] of priority for van der Waals in respect of a certain formula is not justified, and the latter's theoretical result, that the vapour-pressure of a fluid mixture cannot have a maximum value for one particular concentration and a minimum value for another, is not in accordance with Caubet's observations on mixtures of methyl chloride and sulphur dioxide. This is doubtless due to the many arbitrary assumptions on which the theory of the ψ-surface rests. R. E. B.

1540. *Minimum Boiling-points and Vapour Composition.* **M. R. Ebersole.** (Journ. Phys. Chem. 5. pp. 239–255, April, 1901.)—This paper contains an investigation of the boiling-points of mixtures of benzene and acetone. The composition of the vapour-phases was ascertained by the distillation method, using specific-gravity determinations as the method of analysis. The results indicate normal behaviour.

The remainder of the paper is occupied with a valuable summary of the behaviour of pairs of liquids with respects to the following points : (*a*) Intersection of the vapour-pressure curves, (*b*) Existence of maximum or minimum boiling-points.

This was undertaken with a view to further test the theorem propounded by Bancroft, viz., that when the vapour-pressure curves intersect there will exist at some concentration a minimum boiling-point. According to the data existing at present there are five exceptions to the above rule, namely : Acetone and ethyl ; alcohol propyl alcohol and ethyl acetate ; benzene and carbon tetrachloride ; benzene and ethyl acetate ; benzene and isobutyl alcohol. In these cases the vapour-pressure curves intersect, but the boiling-point curves exhibit no minima or maxima. F. G. D.

1541. *Depression of the Freezing-point of Solutions.* **W. F. Magie.** (Phys. Rev. 12. pp. 240–244, April, 1901.)—A theoretical investigation to ascertain whether the departures of some of Loomis' results from van't Hoff's law are to be ascribed to the fact that the van't Hoff formula is only a first approximation. Using van't Hoff's method and dropping the simplifying assumptions, the author deduces a rigorous formula. The final result, however, is that van't Hoff's first approximation is sufficiently exact, and that the deviations observed by Loomis must be explained in some other way. F. G. D.

1542. *Freezing-points of Aqueous Solutions of Non-Electrolytes.* **E. H. Loomis.** (Phys. Rev. 12. pp. 220–239, April, 1901.)—This paper is a con-

tinuation of the work referred to in Abstract No. 884 (1900). After giving an account of observations on his thermometer, showing that the zero is liable to suddenly change, the author gives results obtained with aqueous solutions of milk, sugar, maltose, levulose, dulcite, acetamide, and salicine. These show that equimolecular solutions at extreme dilution have the same freezing-points, except acetamide. For a given electrolyte the molecular depression D, referred to gramme-molecules per litre of solution, changes uniformly with the concentration without maximum or minimum values; maltose is doubtful in this respect. But the molecular depression D′, referred to gramme-molecules per 1,000 grammes of solvent, is either constant for all concentrations or changes uniformly. Isomeric compounds appear to have nearly the same molecular depressions. Non-electrolytes in extreme dilution obey the law analogous to Avogadro's hypothesis, except methyl alcohol, ethyl alcohol, and acetamide. By assuming the gas laws, and throwing van't Hoff's equation into the form—

$$\frac{\Delta}{n} = \frac{RT^2}{NL},$$

in which Δ = depression, n and N are the number of gramme-molecules of solute and solvent respectively, L = latent heat of fusion of one gramme-molecule of solvent, and R, T have their usual meanings, it is seen that the value of D′ should theoretically be constant if the gas laws are obeyed. Exceptions can generally be explained by slight departure from the gas laws; but in the case of aniline the discrepancy is so considerable that it is necessary to assume association. The author's experiments tend to show that the benzene derivatives in aqueous solution form molecular aggregates. There is no evidence of ionisation of non-electrolytes in dilute solution. W. R. C.

1543. *Cryoscopic Investigations of Inorganic Solvents.* **S. Tolloczko.** (Acad. Sci. Cracovie, Bull. 1. pp. 1–22, Jan., 1901.)—The molecular depression of the freezing-point of antimony trichloride is E = 184; arsenic trichloride, when dissolved in antimony trichloride, produces a normal depression, but arsenic bromide produces a considerably larger effect, E = 266–256, and arsenic iodide gives E = 625–555; these abnormal results are probably due to interaction with the solvent and not to ionisation; potassium and mercuric chlorides also give abnormal results, but these are perhaps due to ionisation.

Antimony tribromide has a molecular depression E = 267; when dissolved in this solvent arsenic tribromide appears to be polymerised, E = 177–169, but stannic bromide and antimony chloride give normal results, whilst arsenic iodide again gives a very high value, E = 408–349, probably because of interaction with the solvent.

Arsenic bromide has a molecular depression E = 206, and normal values were obtained for solutions of arsenic iodide and stannic bromide in this solvent, but arsenic chloride gives E = 247–216, and it is suggested that ionisation may possibly occur in this case.

Stannic bromide, E = 305, gives abnormal results (E = 561 and 619) with antimony trichloride, but normal results with antimony tribromide; this is probably due, as in the similar cases mentioned above, to interchange of halogens with the solvent, and not to ionisation.

A rise of the freezing-point, due to the formation of solid solutions, occurs in the case of bismuth trichloride in antimony trichloride, bismuth tribromide in antimony tribromide, and antimony tribromide in arsenic tribromide.

The latent heat of fusion of antimony trichloride is 15·37 Cal. and of the

tribromide 9·73 Cal.; the molecular depressions are hence calculated to be 177 and 274, and agree with those determined cryoscopically. [See also Abstract No. 883 (1900).] T. M. L.

1544. *Decomposition of Ammonium Nitrite.* **R. Wegscheider.** (Zeitschr. Phys. Chem. 36. pp. 543–545, April 2, 1901.)—In 1892 it was shown by Angeli and Boeris that the velocity of decomposition of ammonium nitrite into nitrogen and water is increased by the addition of an electrolyte containing either the ammonium or the nitrite ion. From this observation they concluded that the decomposition occurs only among the non-ionised molecules of the nitrite, the ions taking no part in the reaction. The author shows, however, that the facts are equally well explained on the assumption of an ionic reaction expressed by the equation: $NH_4 + NO_2 = N_2 + 2H_2O$. Thus if V is the volume of solution containing one gramme-molecule of ammonium nitrite and α the degree of dissociation of the salt, the velocity of the decomposition on the assumption that the ions react will be $k\alpha^2/V^2$, k being a constant. If now the volume V contain, besides a gramme-molecule of ammonium nitrite, a certain quantity of either another ammonium salt or another nitrite, yielding a proportion of NH_4 or NO_2 ions represented by β, the degree of dissociation α will be altered to some lower value α' and the velocity of reaction of the ions will be $k\alpha'(\alpha' + \beta)/V^2$. The dissociation constant has the values—

$$K = \alpha^2/(1-\alpha)V = \alpha'(\alpha' + \beta)/(1-\alpha')V \ldots\ldots\ldots\ldots\ldots(1)$$

Also, since α is greater than α',

$$(1-\alpha) < (1-\alpha') \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Multiplication of the expressions (1) and (2) gives: $\alpha^2 < \alpha'(\alpha' + \beta)$. Hence the first velocity of decomposition, $k\alpha^2/V^2$ is less than $k\alpha'(\alpha' + \beta)/V^2$, the velocity when a second salt is present. T. H. P.

1545. *Velocity and Catalysis in Non-homogeneous Systems.* **K. Drucker.** (Zeitschr. Phys. Chem. 36. pp. 693–709, April 19, 1901.)—A continuation of previous work on the subject [see Abstract No. 897 (1901)]. This paper commences with some remarks on the theory of the process of solution in general, and although the author confirms the results obtained by Bruner and Tolloczko [Abstract No. 405 (1901)] he cannot accept their conception of Noyes and Whitney's solution formula as a diffusion function as justified. It is pointed out that in Bruner and Tolloczko's experiments portions of the liquid were removed for analysis from time to time so that the volume varied, and it is shown, both theoretically and experimentally, that the so-called diffusion constant and also the solution velocity vary with the volume. Further experiments on the solution of arsenious oxide show that the influence of the anion in the case of hydrochloric and sulphuric acids is only secondary. Hydroxyl ions exert a much stronger catalytic action than hydrogen ions, and the increase in solution velocity is approximately proportional to the square root of the concentration of the ions. Noyes and Whitney's formula does not hold for the solution of arsenious oxide in dilute sulphuric acid, the velocity of solution being, for constant concentration of the catalytic agent, independent of the concentration of the arsenious oxide up to nearly the saturation point. N. L.

1546. *Theory of Catalytic Reactions.* **H. Euler.** (Zeitschr. Phys. Chem. 36. pp. 641–663, April 19, 1901; from the Öfversigt af K. Svenska Vetenskaaps-

Akad., Förhandl., No. 4, 1899.)—In this paper a large amount of scattered experimental material is discussed in the light of the author's theoretical views. These views may be stated briefly as follows :—

(*a*) *All* chemical reactions occur between ions. (*b*) Catalytic increase of a reaction-velocity may always be traced to an *increase* in the number of the ions taking part in the reaction. (*c*) In all actual chemical reactions the total amount of available free energy cannot be obtained in the form of useful mechanical work outside the system owing to frictional and polarisation phenomena. The effect of a catalyser is to increase in a given time that portion of the available free energy which can be obtained as mechanical work.

The discussion is concerned chiefly with the catalytic acceleration of esterification, saponification, and inversion. F. G. D

1547. *Ionisation: Reply to Arrhenius, Kohnstamm, Cohen, and Noyes.* **W. Nernst.** (Zeitschr. Phys. Chem. 36. pp. 596–604, April 2, 1901.)—In reply to Arrhenius [see Abstract No. 908 (1901)] Nernst asserts that the formula for the p.d. of a concentration cell recently given by Arrhenius and that given originally by himself are *equally valid* from a thermodynamical point of view and hold good provided the "gas" laws apply. He also points out that one can be deduced from the other if Ostwald's "dilution" formula holds good—a fact which has been already pointed out.

The replies to Kohnstamm, Cohen, and Noyes concern small matters of detail for which reference must be made to the original paper. F. G. D.

1548. *Decrease of Osmotic Pressure by Ion-charges.* **V. v. Türin.** (Zeitschr. Phys. Chem. 36. pp. 524–528, April 2, 1901.)—The electrostatic energy of a system of spherical drops of an electrolyte is proportional to the total surface, and its magnitude per unit area is given by the equation—

$$W = 0{\cdot}4\,Q\,.\,K\,.\,D^{-1}\,.\,q,$$

where Q is the total charge on unit mass of hydrogen-ions (96,537 coulombs), K the concentration of the solution in gram-equivalents per c.c., D its dielectric capacity, and q the charge on an ion. For an aqueous solution the electrostatic energy per unit area is given in ergs by the equation—

$$w = 1{\cdot}5 \times 10^{9} k\,.\,q,$$

where k is the concentration in gram-equivalents per litre, and q the charge on an ion. [See also Abstract No. 2284 (1900).] T. M. L.

1549. *E.M.F. and Osmotic Pressure.* **R. A. Lehfeldt.** (Phys. Soc., Proc. 17. pp. 577–604; Discussion, p. 605, July, 1901; and Phil. Mag. 1. pp. 377–403, April, 1901.)—Assuming the validity of the simple gas laws for solutions the author deduces thermodynamically the following equation :—

$$E = \frac{RT(1-x)}{r\varepsilon}\left((n-1)(\gamma_2-\gamma_1) + \int_{C_1}^{C_2}\{1+(n-1)\gamma\}\frac{dC}{C}\right)$$

where E = e.m.f. of a concentration-cell, in which the solutions have concentrations C_1 and C_2,

r = least common multiple of valencies of the ions,

n = number of ions formed from a molecule of electrolyte,

x = transference ratio for the kation,

γ = degree of ionisation.

The conclusion is drawn from this that the e.m.f. depends not on the osmotic pressure of the *metallic* ions only, but on that of the solution as a whole.

If the gas laws be not assumed, then deviations from Boyle's law may be allowed for by writing for the osmotic pressure $P = RTiC$, where i is no longer identical with $1 + (n - 1)\gamma$; in this case the previous equation becomes—

$$E = \frac{RT(1-x)}{re}\left(i_2 - i_1 + \int_{C_1}^{C_2} \frac{i dC}{C}\right).$$

Applying this equation to the case of zinc in zinc chloride solution, it is found that the electrolytic solution-pressure of zinc need only be regarded as of the order of magnitude of 20,000 atmospheres instead of the value 10^{19} atmospheres required by Nernst's theory.

Measurements are given of the e.m.f.'s of concentration-cells with zinc electrodes, containing (*a*) zinc chloride, (*b*) zinc sulphate solutions. These measurements are employed to determine the osmotic pressures of the concentrated solutions and the corresponding values of PV.

Very considerable deviations from Boyle's law are found to occur. F. G. D.

1550. *E.M.F. and Osmotic Pressure.* **F. Krüger.** (Zeitschr. Phys. Chem. 36. pp. 87–90, Jan. 22, 1901.)—In reply to Lehfeldt, the author points out that Nernst's formula for the e.m.f. of a concentration-cell can be deduced from the thermodynamical formula given by Lehfeldt by *assuming the validity of the Ostwald dilution-law.* From this he concludes that Lehfeldt's formula is not new. F. G. D.

1551. *Electrocapillary Phenomena.* **W. Palmaer.** (Zeitschr. Phys. Chem. 36. pp. 664–680, April 19, 1901.)—A discussion of the theories of Helmholtz, Warburg, and Nernst.

(*a*) Helmholtz's theory, in which the mercury electrode is regarded as acting as an insulating condenser surface and in which no actual separation of ions is supposed to occur, offers no explanation of the "natural" p.d. between mercury and ordinary sulphuric acid. Moreover, the Helmholtz explanation of the p.d. between a "dropping" mercury electrode and a quiescent mercury electrode in the same solution requires the assumption that a not inconsiderable period is necessary for the development of the natural p.d. between a freshly formed mercury surface and the sulphuric acid solution. There is no incontestable evidence for this, as the facts brought forward by König can be very simply explained by Nernst's theory.

(*b*) Warburg's theory was an important advance, as it recognised the fact that ordinary sulphuric acid contains dissolved oxygen, and soon dissolves some mercury, so that there are mercury ions concerned in the phenomena. Hence when an external p.d. is applied to a Lippmann capillary electrometer, a true conduction current ensues whereby the concentration of the mercury ions at one electrode is increased and at the other diminished, and so a compensating (reverse) e.m.f. produced. In order to explain the high p.d. (0·8 volt) between a dropping and a quiescent mercury electrode in a sulphuric acid solution, Warburg was forced to assume that mercury had the power of "condensing" a concentrated film at its interface with the solution. This hypothesis, however, will not answer the purpose, as it would require the presence in the condensed layer of at least $2 \cdot 10^{14}$ kilograms of mercury per cubic millimetre.

(*c*) Nernst's theory is simply an application of the theory of solution-pressure to the particular case of mercury. It offers an explanation of the polarisation of the Lippmann electrometer similar to that given by Warburg. It supplies, however, a satisfactory explanation of the high p.d. obtained with the dropping electrode, for on account of the low electrolytic solution-pressure of mercury, mercury ions are deposited on every fresh surface, and so the concentration of the mercury ions at the dropping electrode is continually diminished. This process is only compensated by disturbing effects such as convection, stirring of the liquid, &c., and under suitable conditions may proceed very far.

The paper contains further a discussion of G. Meyer's extension of Warburg's "condensation" theory to the case of dropping electrodes in which amalgams are used, wherein the author endeavours to prove that the phenomena can be explained by means of Nernst's theory without the hypothesis introduced by Meyer. The reader must be referred to the original paper for the details of this discussion.

In conclusion it is pointed out that although the majority of the observed phenomena can be explained by an application of Nernst's general theory without the introduction of new hypotheses, nevertheless there remain several outstanding facts for which there exists as yet no satisfactory explanation. Chief among these is the unsymmetrical character of the relationship between surface tension and applied p.d., as observed in the Lippmann capillary electrometer. F. G. D.

1552. *Iron and Steel from the Standpoint of the Phase-Rule.* **F. Osmond.** (Metallographist, 4. pp. 150–161, April, 1901 ; from the Bulletin de la Société d'Encouragement, Nov. 30, 1900.)—This and the following Abstract form a criticism of Roozeboom's paper of the same title [Abstract No. 2275 (1900)].

A sample of iron containing not more than 2 per cent. of carbon exists at high temperatures exclusively in the form of mixed crystals of γ-iron and carbon, but when slowly cooled it is converted into a mixture of *ferrite* or α-iron and *cementite* (Fe_3C), the iron passing into the magnetic modification which is stable at ordinary temperatures, and the whole of the carbon being converted into carbide. By rapid cooling the forms stable at high temperatures are more or less preserved, and it is now suggested that *austenite*, which occurs as a constituent of chilled steel, is probably identical with the mixed crystals which are stable at high temperatures ; *martensite*, which is usually regarded as identical with the mixed crystals of γ-iron and carbon, appears to represent the first stage in the transformation of austenite into ferrite-cementite ; it is produced by quenching in cold water small samples of iron containing not more than 1·10 per cent. of carbon, and corresponds to the maximum of hardness for the given content of carbon. *Troostite* is a transition form approaching more nearly to that stable at ordinary temperatures ; it is produced by a mild quenching (in oil or boiling water) of small pieces of steel, by sudden cooling during recalescence, or by a mild tempering of martensite. *Sorbite* approaches still more nearly to the condition which is stable at ordinary temperatures, and may perhaps be regarded as an imperfectly separated mixture of ferrite and cementite ; it is produced by cooling small samples in air, by quenching in cold water towards the end of recalescence, by quenching in molten lead, or by tempering martensite to a blue colour. No sharp line of demarcation can be drawn between troostite and sorbite, and it is probable that they do not represent a condition of equilibrium, and are therefore not amenable to the phase-rule ; Rooze-

boom is therefore probably right in limiting his treatment to α-, β-, and γ-iron, together with graphite, cementite, and the mixed crystals of γ-iron and carbon which he calls martensite, but which more closely resemble austenite.

Below 1,000° the graphite which separates from an iron containing between 2 per cent. and 6·6 per cent. of carbon should be converted into cementite, whilst above this temperature the reverse change should take place; in confirmation of this an experiment is quoted, in which more than half of the carbon (3·85 per cent., all combined) of a sample of cast iron was converted into graphite by heating to 1,030°, whilst, on the other hand, a soft cementation steel containing 1·38 per cent. graphite and only 0·24 per cent. of combined carbon was converted into a hard steel with a large proportion of combined carbon by heating to 780°–950° T. M. L.

1553. *Iron and Steel from the Standpoint of the Phase-Rule.* **H. le Chatelier.** (Metallographist, 4. pp. 161–170, April, 1901; from the Bulletin de la Société d'Encouragement, Nov. 30, 1900.)—No less than eleven different phases are possible in a mixture of iron and carbon, but by the phase-rule it is shown that, neglecting the gaseous phase, (1) four phases can never exist together in equilibrium, and if four phases are detected the system is still undergoing change; (2) three phases can exist together only at a definite temperature and with a definite composition of each of the three phases, the relative proportions of which may alone vary; (3) two phases can exist together at any temperature, but the composition of these phases is dependent on the temperature and can only be made to vary by changing the temperature; (4) one phase may exist at any temperature, and the composition of the phase can also be varied arbitrarily. By these rules the determination of the equilibrium between the eleven possible phases is greatly simplified, and becomes a practicable problem.

It is shown that the curve representing the melting-point of mixtures of iron and carbon shows a slight break at 2·25 per cent. of carbon and a temperature of 1,275°; if this can be clearly established it is of considerable importance as showing that two different solid phases separate from the liquid at different temperatures, and these would probably be identical with austenite and martensite; this is thought to be more probable than Osmond's suggestion that martensite is a partially changed austenite.

When steel containing 0·9 per cent. of carbon is heated to the recalescence-point a *double* change occurs, which is made manifest by a sudden contraction in volume followed by an equal expansion. When quenched at the beginning of the contraction the steel was found to consist entirely of pearlite (a eutectic mixture of ferrite and cementite representing the stable equilibrium at ordinary temperatures); quenched at the maximum contraction it consisted almost entirely of troostite with a little pearlite and martensite; quenched at the end of the expansion it consisted entirely of martensite. This shows that the change is probably that represented by the scheme :—pearlite $\longrightarrow$ troostite $\longrightarrow$ martensite, and suggests that troostite is a modification which is stable within a very narrow range of temperature near the recalescence-point. T. M. L.

1554. *Amphoteric Electrolytes and Lactonic Salts.* **K. Winkelblech.** (Zeitschr. Phys. Chem. 36. pp. 546–595, April 2, 1901.)—The author first explains the meaning of the term "amphoteric" as applied to electrolytes, and gives the various classes of compounds to which the name is applied

together with their reactions. Prominent among these compounds, which function both as acids and bases, are the amino-acids. The determination of the acidity and basicity constants of such substances may be carried out by measuring the extent to which the salts formed by them with strong acids and with strong bases are hydrolysed. To this end the author uses partly the determination of the change of electrical conductivity produced by adding an amphoteric electrolyte to a solution either of hydrochloric acid or of sodium hydroxide, and partly the measurement of the catalytic influence of the free hydrogen or hydroxyl ions on the decomposition of ethyl acetate. These methods are applied to the investigation of betaïne, sarcosine, leucine, glycocoll, alanine, taurine, asparagine, *o*-, *m*- and *p*- amino-benzoic acids, aspartic acid, hippuric acid, sulphanilic acid, amino-sulphonic acid, methyl orange, hydroxylamine, hydrocyanic acid and urea. The results obtained do not point to any simple relation between the acidic and basic functions of the groups in any one molecule, but in some series of analogous compounds the acidity and basicity are found to increase together. This is the case with the aminobenzoic acids, and with these also the greatest diminution in the acidic and basic functions occurs when the amino- and carboxyl-groups are in the ortho-position. Simultaneous increase of acidity of basicity also obtains with the series, alanine, glycocoll, leucine, sarcosine, and betaïne. For glycocoll, sarcosine, and betaïne the acidity decreases more rapidly than the basicity, whilst for the aminobenzoic acids the reverse holds. With regard to the amino-acids, which are usually regarded as having a lactonic or anhydride structure, the results indicate that their aqueous solutions contain for the most part non-dissociated hydrolysed molecules, due to the water acting as a weak base or acid and combining with the acidic or basic group of the amino-acid. T. H. P.

1555. *New Method for the Measurement of Ionic Velocities.* **B. D. Steele.** (Chem. Soc., Journ. 79. and 80. pp. 414–429, April, 1901.)—The method is a modification of that introduced by Lodge (B.A. Report, 1886, p. 395) in which the velocity of an ion is measured directly by means of the movement of the boundary between a colourless and two coloured salts in a gelatinised electrolyte during the passage of a current. The use of gelatine is largely avoided by employing vertical tubes, and it has been found to be possible under certain conditions to observe the boundary between colourless solutions by means of slight differences in density and refractive power, so that the use of a coloured solution is also rendered unnecessary.

In the case of magnesium sulphate concordant results were obtained by noticing the velocity of motion of the boundary in the systems, $CuSO_4$ | $MgSO_4$ | $K_2C_2O_4$, $CuSO_4$ | $MgSO_4$ | $NaC_2H_3O_2$, and $CdSO_4$ | $MgSO_4$ | $NaC_2H_3O_2$, but the ratio of the anion and kation velocities differed from the value obtained by Masson in gelatinised solutions, showing that the gelatine affects the two ions unequally. The chlorides and bromides of sodium and potassium were examined in a similar manner, using lithium chloride and sodium acetate as indicator solutions. In the case of these salts the values obtained differed only slightly from those observed by Masson in gelatinised solutions.

For details of the apparatus used and the conditions necessary for securing well-defined boundaries reference must be made to the original paper.

T. M. L.

1556. *Electrolytic Phenomena in Secondary Circuits of Induction Coils.* **K. R. Johnson.** (Ann. d. Physik, 3. 4. pp. 744–748, 1900.)—A water

voltameter in which the electrodes are platinum points is put into the secondary circuit of an induction coil, and the make and break is done by hand. Gas bubbles are observed to stream from each electrode at break, but none at make. This electrolysis is put down to electric waves arising at break. In another experiment in which the interrupter of the coil is used, the gases given off have volumes in the ratio 2 to 1. But these gases explode, and it is found on absorbing the oxygen that the volumes are each reduced by one-third, the inference being that each amount contained equivalent volumes of H_2 and O_2. The difference in the amounts given off at the two electrodes is ascribed to asymmetry of the inductors, and can be eliminated by adding a suitable resistance to the primary. By varying the capacity of the condenser in the primary circuit it is shown that the amount of gas given off per unit of time is inversely proportional to $\sqrt{\text{capacity of primary condenser}}$. The actions of Holtz's machine and the induction coil are similar, the amount of gas set free being very much greater in the case of the coil. G. E. A.

1557. *Electrolytic Purification of Mercury.* **W. McA. Johnson.** (Elect. World and Engineer, 37. p. 634, April 20, 1901.)—This paper gives an account of some experiments made with a view to the removal of the small impurities present in ordinary commercial mercury. About 1 kilogramme of mercury was placed in a crystallising dish and covered with 500 c.c. of a solution of KNO_3 (4 per cent.) and HNO_3 (17 per cent.). The electrical connection was made to the mercury by means of a platinum wire sealed into a glass tube passing through the solution. The kathodes were two carbon rods. A careful arrangement of the electrical circuit was employed to regulate the current, and it was found that a voltage of from 0·75 to 1·0 volt could be employed whereby the Sn, Cd, Pb, Cu, &c., were carried into solution with very little mercury. The solution was changed several times, and after six hours' electrolysis the mercury was very mobile and left no discolouration on porcelain. No analyses, however, are given. Low-current density gives the best results. The author thinks that this method may be of service where a steady current is available as an alternative to the method of dropping finely divided mercury through a long tube filled with HNO_3.
J. L. F. V.

1558. *Commercial Electrolysis of Water.* **W. Dürer.** (Elektrochem. Zeitschr. 8. pp. 1–2, April, 1901.)—The author discusses some of the difficulties met with in the electrolysis of water for industrial purposes. The danger of producing detonating gas when using metallic diaphragms is pointed out, and reference is made to Bassani's automatic attachment for checking the specific gravity of the hydrogen gas as it issues from the electrolytic apparatus. The absorption of carbonic acid gas from the air by the caustic soda solution used as electrolyte in the cell is a second difficulty. This is overcome by working the cell at a fairly high temperature, or by covering the electrolyte with a layer of oil. As regards the use of the electrolytic gases, it is pointed out that hydrogen prepared in this way is more suitable for military balloons than hydrogen prepared by acting on iron with sulphuric acid, since it is purer than the latter. The weight of pure hydrogen is 89 grms. per cubic metre. The corresponding figures for electrolytic and for chemical hydrogen are 107 and 160 grms. respectively.

Hydrogen gas produced by electrolysis of water is odourless, and on this account it is difficult to detect leaks in the apparatus or gas-holders. In order

To overcome this objection to the gas it is necessary to add a little mercaptan to each vessel containing the gas. Reference is made to the installation of an apparatus for the electrolysis of water at Rome. [See Abstract No. 539 (1901).] J. B. C. K.

REFERENCES.

1559. *Estimation of Metals by Electrolysis.* **C. Nathan.** (Electro-Chemist, 1. pp. 46–47, Feb.; 59–60, March; 85–86, April, 1901.)—This paper comprises a brief historical account of the introduction of electrolytic methods into chemical analysis, a description of the apparatus in general use and of the principles involved, and brief directions for the estimation of the more important metals and alloys. N. L.

1560. *Ionisation of an Electrolyte in a Mixture of Electrolytes.* **Y. Osaka.** (Zeitschr. Phys. Chem. 36. pp. 539–542, April 2, 1901.)—Let d = degree of ionisation of the electrolyte in question, K = its dissociation constant, T = total number of all the anions or kations present. Then for binary electrolytes obeying the law of mass action—

$$d = \frac{K}{K + T}$$

This theorem has been already employed by Arrhenius. The author directs attention to it, and gives a proof of it in the general case of n binary electrolytes. F. G. D.

1561. *Annual Report on Atomic Weights.* **F. W. Clarke.** (Chem. News, 83. pp. 161–162, April 4; and 169–170, April 12, 1901. From the Journal of the American Chemical Society, 23. No. 2.)

1562. *Reducing Power of Calcium Carbide.* **Fr. v. Kügelgen.** (Zeitschr. Elektrochem. 7. pp. 541–550, April 11; 557–568, April 18; and pp. 573–580, April 25, 1901.)

1563. *Physico-Chemical Studies of Tin. IV.* **E. Cohen.** (Zeitschr. Phys. Chem. 36. pp. 513–516, April 2, 1901.)—Quotations are given from Aristotle, Plutarch, and Montaigne, showing that the crumbling of white tin into grey tin during extreme cold has been known from classical times. [See further, Abstract No. 529 (1901).] T. M. L.

1564. *Theory of Electrolysis.* **G. Platner.** (Elektrochem. Zeitschr. 8. pp. 8–11, April, 1901.)—A theoretical paper on the same lines as some previous papers by the author [see Abstract No. 1378 (1898), and No. 1214 (1899)]. The phenomena of electrolysis are not considered to be fully explained by the theory of electrolytic dissociation. Stress is laid on the unity of electricity, hydrolytic dissociation, and the function of the solvent in electrolysis. A satisfactory solution of the problems involved is to be sought in a more intimate knowledge of chemical and molecular forces. N. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1565. *Engines for the Brooklyn Edison Plant.* (Amer. Electn. 13. pp. 108–110, March, 1901.)—Each engine is vertical cross-compound with Corliss gear, having cylinders 46 and 86 inches by 60 inches stroke. Its most economical speed is 75 r.p.m., developing 3,750 h.p., but it will run up to 7,500 with safety. The h.p. cylinder clearance is 3 per cent. and the l.p. 2 per cent. Steam jackets are not used, as the Westinghouse Company find that after a piston speed of 600 feet per minute they are of little or no use. A reheater, however, is employed in the receiver having a surface of 1,500 square feet. Higher values of reheating surface have been advocated by some builders, but this proportion gives very good results and has certain distinct advantages. The steam passing through the engine is passed through the inside of the heater tubes, and boiler steam is used on the outside. The connecting rods are 5½ crank-lengths. The shaft is hollow, 39 inches diameter within the flywheel, 34 inches in the bearings, and weighs 75 tons without the centre. The construction of the flywheel is novel; the segments and arms are of cast steel and the centre of wrought iron. There are five centre rim segments, each cast in one piece, with two of the arms; this effectually prevents any two joints coming diametrically opposite to one another. On either side of the centre segments are disposed five plates linked together, and so arranged as to break joints with the centre segments to which they are riveted. This form of construction practically results in three flywheels, each self-supporting as to centrifugal force.

The most novel feature of this engine is the safety stop arrangement, which consists of a small weight pivoted in the crank cheek and held in position by a spring. When the speed exceeds a certain limit the weight flies out, overcomes the action of the spring, and hits a small lever. This lever works a three-way cock that admits steam to a cylinder controlling a valve in the main steam-pipe. When steam is admitted to this cylinder it closes the valve, shuts off the steam, and so stops the engine. Steam can also be admitted by hand to this cylinder from the engine platform, thus stopping the engine. Forced lubrication is used throughout the engine.

L. S. R.

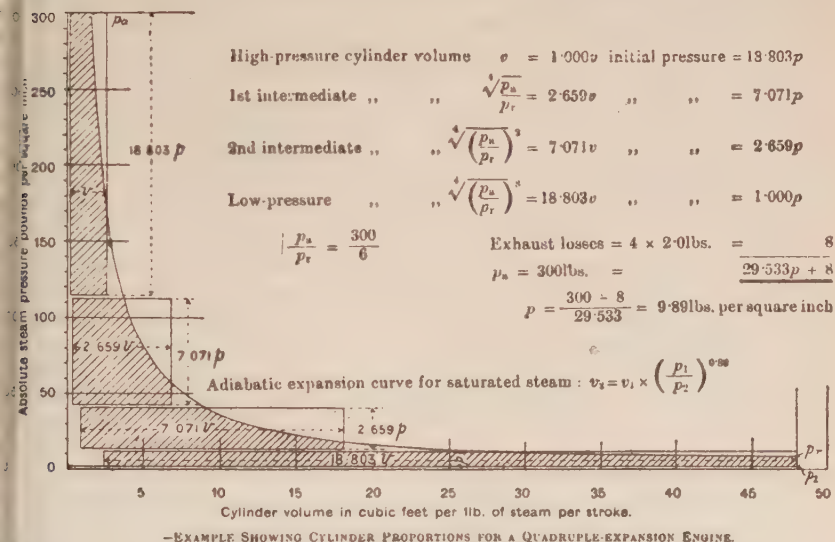
1566. *Proportions of Cylinders for Multiple-Expansion Engines.* **A. Hanssen.** (Mech. Eng. 7. pp. 602–605, April 27, 1901. Paper read before the Civil and Mechanical Engineers' Society, April 4, 1901.)—Although the correct design of cylinders and valve gear cannot make an engine economical if other conditions are unfavourable, it is important to have the work done in each of the cylinders equal, especially where each cylinder operates a separate crank. As an example of the often under-estimated or almost neglected effects of radiation in causing condensation in the cylinders, the author quotes an instance where the steam consumption per i.h.p.-hour was diminished by 49 per cent. simply by increasing the thickness of lagging, on all the steam-heated surfaces, from 1 inch to 3 inches.

Although sufficient initial super-heat to allow of the steam being above

the saturation temperature at release is generally not permissible, adiabatic expansion should at all events be striven for. The author gives a semi-graphical method of finding the cylinder proportions from the curve of adiabatic expansion. If n be the number of cylinders, p_a the initial pressure, and p_r that at release, the diagram is divided vertically into n parts in the proportion—

$$1 ; \left(\frac{p_a}{p_r}\right)^{\frac{1}{n}} ; \left(\frac{p_a}{p_r}\right)^{\frac{2}{n}} ; \ldots \left(\frac{p_a}{p_r}\right)^{\frac{n-1}{n}},$$

and horizontally into n parts, each part inversely proportional to the range in pressure of the corresponding part of the diagram. There are thus


High-pressure cylinder volume v = 1·000v initial pressure = 18·803p
1st intermediate ,, ,, $\sqrt[4]{\frac{p_a}{p_r}}$ = 2·659v ,, ,, = 7·071p
2nd intermediate ,, ,, $\sqrt[4]{\left(\frac{p_a}{p_r}\right)^2}$ = 7·071v ,, ,, = 2·659p
Low-pressure ,, ,, $\sqrt[4]{\left(\frac{p_a}{p_r}\right)^3}$ = 18·803v ,, ,, = 1·000p
$\frac{p_a}{p_r} = \frac{300}{6}$
Exhaust losses = 4 × 2·01lbs. = 8
p_a = 300lbs. = 29·533p + 8
$p = \frac{300 - 8}{29·533}$ = 9·891bs. per square inch
Adiabatic expansion curve for saturated steam : $v_2 = v_1 \times \left(\frac{p_1}{p_2}\right)^{0·96}$
Absolute steam pressure, pounds per square inch
Cylinder volume in cubic feet per lb. of steam per stroke.

—Example Showing Cylinder Proportions for a Quadruple-Expansion Engine.

obtained n rectangles of equal area approximating to the shape of the curve. The indicator diagrams contained in these n rectangles are very nearly equal in area. An example of quadruple expansion is given in the figure. This gives the proportion; the actual area of the low-pressure cylinder being given by $a = \frac{\text{i.h.p.} \times 33{,}000}{p_m \times S}$, where S = piston speed and p_m = total mean pressure reduced to low-pressure cylinder. H. R. C.

GAS AND OIL ENGINES.

1567. *Power Gas and Large Gas Engines.* **H. A. Humphrey.** (Inst. Mech. Engin., Proc. 1. pp. 41–118; Discussion, pp. 119–247, Jan., 1901.)—In an appendix the author gives the cost of 1 b.h.p.-hour in manufacturing works, as the mean of a large number of actual results; it varies from 0·68d. for ordinary works with fairly uniform load to 1·80d. for small works with varying load.

A description is given of the Mond gas-producer, illustrated by five diagrams and four photographs. Common bituminous slack is used as fuel, and is fed into the producer bell. On reaching the hot zone of fuel the tar is converted into a fixed gas, and the slack then descends into the body of the

producer, where it is acted on by an air-blast, which has been saturated with steam at 85° C. and superheated. The steam used per ton of fuel gasified is 2½ tons; this large quantity keeps the temperature of the producer within such limits as to prevent the formation of clinkers or the destruction of the ammonia. Half a ton of steam is decomposed per ton of fuel burnt, yielding 29 per cent. by volume of hydrogen in the final gas. The hot gas and undecomposed steam, leaving the producer, pass first through a tubular regenerator in the opposite direction to the incoming blast. An exchange of heat takes place, and the blast is still further heated by passing down the annular space between the two shells of the producer. The hot gases then pass through a washer, in which they meet a water-spray thrown up by revolving dashers, and are thereby cooled to about 90° C. The gas then passes upwards through a lead-lined tower filled with tiles, where it meets a downward flow of acid liquor circulated by pumps, consisting of sulphate of ammonia with about 4 per cent. free sulphuric acid. The ammonia of the gas combines with the free acid, yielding sulphate of ammonia, and, to make the process continuous, some sulphate liquor is constantly withdrawn or evaporated, while free acid is added. The gas, now freed from ammonia, passes up a cooling tower, where it meets a downward stream of cold water. The heated water is utilised in an air-heating tower to heat the air-blast from the blowers. In Appendix 1 are given figures relating to the Mond plant and gas. The composition of the gas is, in volumes per cent., 11 of CO, 29 of H, 2 of CH_4, 16 of CO_2, and 42 of N. The calorific value of the fuel used was 6,900,000 large calories per ton of dry fuel. A ton of moist fuel yields 4·02 cubic metres of gas, of a calorific value of 1,414 large calories per cubic metre. The efficiency of production is 84 per cent. One volume of Mond gas requires 1·15 volumes of air for complete combustion, and gives a theoretical temperature of 1,610° C. The ammonia recovered is about 1 per cent. by weight of the fuel gasified, and has a value of about 8s. per ton of fuel, which at the pit costs 2s. 6d., and delivered at Winnington 6s. 9d. per ton.

Coming to gas engines, in Appendix 3 are given particulars of some large engines; a Crossley engine of 450 i.h.p. and a Premier engine of 650 i.h.p. are running day and night on Mond gas at Brunner, Mond & Co.'s works; a 700-i.h.p. Simplex engine is running on blast furnace gas at Seraing, and two 1,500-i.h.p. Westinghouse engines are being built for use with natural gas. In Appendices 4 and 14 are given full particulars of the above-mentioned Crossley and Premier gas engines, and of some large Œchelhäuser and Otto engines; these are illustrated by numerous diagrams and photographs. In Appendix 5 are given the results of tests on the Crossley and Premier engines, running with Mond gas. The Crossley engine has two cylinders, 26 inches by 36 inches stroke. Working at 314 b.h.p. at 152 r.p.m. the mechanical efficiency was 90·76 per cent., and the thermal efficiency (i.h.p.) 27·2 per cent.; the consumption of Mond gas was 60 cubic feet per i.h.p.-hour, or 72 cubic feet per b.h.p.-hour. Diagrams of the valve motion are given, and indicator diagrams, showing a maximum pressure of about 240 lbs. per square inch, with an effective pressure of 63 lbs. per square inch, and a clearance of about 26 per cent. of the working stroke; there are also given diagrams taken with a light spring, of firing cycles, and cycles taking air only, and curves are given, showing at different speeds the h.p. lost in running idle, the h.p. lost in fluid resistance when exploding, and the percentage of return stroke when the compression curve crosses the atmospheric line.

The Premier engine is a two-cylinder tandem engine with positive scavenging and water-cooled pistons; the cylinders are 28½ inches by 30 inches stroke.

The engine worked at 368 b.h.p. at 128 r.p.m. The mechanical efficiency was 81 per cent., and the thermal efficiency (i.h.p.) 30·4 per cent. ; the consumption of Mond gas was 52 cubic feet per i.h.p.-hour, or 69 cubic feet per b.h.p.-hour. One i.h.p.-hour was obtained from 0·88 lb. of moist bituminous slack, containing only 62 per cent. of carbon. Indicator diagrams are given showing a maximum pressure of 325 lbs. per square inch, and an effective pressure of 108 lbs. per square inch ; the amount of the clearance is 27 per cent. of the working stroke.

Appendix 6 gives the results of an official trial of a 60-n.h.p. Crossley engine coupled to a Siemens dynamo, and supplied with Mond gas. Appendix 7 is a report on the working of this engine ; during 1898 and 1899 it ran during 96·6 per cent. of the whole time, at an average i.h.p. of 115, and has run for 3,300 hours without a stop. The average consumption during the two years was 67·7 cubic feet of Mond gas, or 1·055 lbs. of slack, per i.h.p.-hour, and 117·3 cubic feet or 1·82 lbs. of slack per e.h.p.-hour. Appendix 8 contains figures relating to the test of a 65-b.h.p. Westinghouse engine with natural gas, and gives indicator diagrams.

Appendix 13 gives a large number of tests with very full particulars of various Continental engines, namely, a test by Witz on a 200-h.p. Simplex engine at Seraing, and one by Hubert on a 600-h.p. engine at the same place, the engines using blast furnace gas. The heat balance-sheet given by Hubert for the 600-h.p. engine is—

Heat converted into work in the cylinder.....	28	per cent.
Heat carried away by water.....	52	„
Heat carried away by gases and losses	20	„

Eight pages of this Appendix are occupied by brake trials conducted by Delamare, Debouttevillc, and Cockerill on a 600-h.p. engine working with blast furnace gas.

Appendix 10 gives comparative figures of the cost of fuel per kw.-hour with steam and gas. Unwin's ideal estimate for continuous running made the cost 0·194d. per unit ; Kennedy's ideal estimate for a central station gave 0·210d. ; the average cost for eighty-three electric light stations is 0·778d. ; the actual cost with Mond gas at Winnington is 0·048d. Appendix 9 contains an estimate of capital and running costs for a 20,000-h.p. central station gas plant, worked with Mond gas at various load factors.

The author made experiments on the speed variation during the strokes of the Crossley and Premier engines, by means of an electric tuning-fork tracing vibrations on a smoked drum. Diagrams are given for both engines showing, throughout the stroke, the inertia forces due to the reciprocating parts, the indicator diagram corrected for inertia, the turning moment on the crank-shaft, and the speed. In the Crossley engine, with both cylinders firing every time, the variation from the mean speed at full load was 0·094 of 1 per cent., and on the "hit and miss" system at three-quarter load it was 0·976 per cent. Curves are given showing the variation of efficiency due to variation in the gas mixture ; the curves are sufficiently flat to show that governing is possible by controlling the admission of gas, instead of by the usual hit-and-miss system. Appendix 12 contains a full table of gases saturated with water vapour at different temperatures, and Appendix 11 details the precautions taken to ensure accuracy in the author's experiments.

Discussion.—**W. J. Crossley** referred to the tests of his gas engine, and explained the reasons which led him to adopt low compression. He gave indicator diagram and figures relating to a test of a 150-i.h.p. engine, which

with coal gas showed a thermal efficiency of 31·8 per cent. He had given much attention to the fluid resistance of engines when missing a stroke, and had devised methods for cutting off the gas at any desired portion of the stroke so that the piston made a slight vacuum which assisted its return. He believed that the irregular sequence of explosions in his tandem engines was the best, as it made possible a far better design of engine. He had a small Mond gas plant at his works, which ran successfully except that the sawdust in the scrubbers required very frequent changing. **J. E. Dowson** spoke on the necessity of gas holders; he thought it would not be safe to work large engines without a gas holder to check the great fluctuations of pressure caused by the suction of the piston. He supposed the reason that no gas holder was used at Winnington was that only a very small proportion of the gas generated was used in the engines, and that the large gas mains acted as a gas holder. He considered the proportion of 16 per cent. of CO_2 contained in the gas called for some improvement, and expected that if worked without sulphate recovery, the plant would not give very economical results. **A. Rollason** gave particulars of a Mond plant of 1,000 i.h.p. erected at the Premier gas-engine works, without sulphate recovery. At full load, 1 lb. of Nottingham slack gave 72·25 cubic feet of gas, of a calorific value of 145·9 B.Th.U. per cubic foot, while at one-third load it gave 70·85 cubic feet, of 144·5 B.Th.U. The calorific value of the slack was 12,200 B.Th.U. per lb., and the thermal efficiency of the producer was 86·4 per cent. The stand-by losses for fourteen hours out of the twenty-four were, at full load 3 per cent., and at one-third load, 5·7 per cent. of the total fuel consumed. **F. W. Burstall**, in speaking of governing by throttling, said that the troubles found were due to failure in ignition; the only way to properly ignite a weak mixture was by the electric spark, with a variable lead, depending on the mixture. He agreed with Slaby in believing that combustion was complete at the point of maximum temperature, but said that when the charge was extremely weak and the burning slow, there occurred sometimes after-burning, which gave an expansion line just above the adiabatic. According to theory this should give inferior efficiency, because the heat was not added at the maximum temperature, and he had made experiments which bore out this conclusion. **W. Dixon** said there were gas producers with recovery plants in Great Britain of larger size and giving better results than the Mond producer. He criticised the author's figures comparing costs of power on the Mond system and in central electric stations. **D. Clerk** said that the high temperature proper to the production of good gas was antagonistic to the production of ammonia; Mond kept down the temperature by the use of steam in great quantity, and had consequently to make arrangements to recover the heat. He did not consider the producer efficient; the figure of 84·1 per cent. given as the thermal efficiency was misleading, as no account was taken of the heat introduced in the form of steam; allowing for this the efficiency came down to 67 per cent. Further, the quantity of gas generated had not been measured, but only deduced from the weights of carbon in the fuel and that lost in tar and in deposits in the flues. He did not think the efficiency could be over 50 per cent. Referring to Crossley's engine, as the piston was not water-cooled, he thought the makers were right in keeping the compression down to 60 lbs. per square inch. The expansion of the piston was so considerable in large engines that a large clearance had to be left to avoid seizure. **B. Donkin** gave tables showing the results of twelve gas engine tests with power gas of 150 B.Th.U. per cubic foot, and of six tests of gas engines in America using natural gas, with a calorific value of about 1,000

B.Th.U. per cubic foot. As regards the calorific values of the gases given by the author, he thought the lesser value should be taken, as this was the custom in all countries except France. He compared the thermal efficiency (b.h.p.) of various engines. It varied from about 12 per cent. with steam to about 30 per cent. with oil engines, which were more efficient than gas engines. **W. Robinson** had tested the Mond gas plant and a 500-h.p. Premier engine at Sandiacre, and found a thermal efficiency of over 30 per cent. He noted the remarkable uniformity in the quality of the Mond gas. He was convinced of the accuracy of the author's estimate of the quantity of gas, as calculated from the carbon. The efficiency found at Sandiacre for the Mond producer was 70 per cent. In the Dowson gas producer the composition of the gas was very variable; in a two-days' test, with regular charging and constant steam pressure, it varied between 137 and 170 B.Th.U. per cubic foot. **W. J. Crossley** compared the figures given for his engine and the Premier engine, showing that the friction loss in the latter was 18·78 per cent., while in his it was 9·33 per cent.; he thought that positive scavenging, which accounted for this difference, was too expensive. **E. B. Ellington** criticised the author's comparative figures for the cost per unit in actual and ideal steam stations and in a Mond gas station. He considered that the total cost for fuel with Mond gas would be 0·15d. instead of 0·048d. In the London Hydraulic Power Company's Wapping station, for the whole year the cost per unit of fuel was 0·215d., and of all station charges 0·465d.; the load factor was only 39 per cent. From a comparison of the costs and the thermal efficiencies of steam and gas engines, he concluded that the efficiency of a steam boiler was about the same as that of a gas producer. He thought that the saving in fuel obtained by the Mond gas plant was of little importance for central stations, as the rates and charges on capital cost were far more important factors. **J. H. Hamilton** compared the Premier and Crossley engines, to the advantage of the former; he gave full particulars of the Premier engine, pointing out, among other things, that the compression every back-stroke was so arranged that there was never a pull on the connecting rod, thus avoiding all knocking at the joints. **W. C. Goodchild** gave particulars of the gas plant erected by the Midland Railway Company at Leicester. In the last half-year the fuel consumed was 3·1 lbs. per unit, costing 0·34d.

The Author, in reply, said that the cost of sawdust, shavings, and labour in cleaning and refilling the scrubbers amounted to 4d. a day for a 1,000-h.p. plant running continuously. The time taken to start the Crossley 400-h.p. gas engine from rest and to parallel it with the others was 2½ minutes. The engine had run for 57 days with only two stops required by the electrical plant. The balance-sheets of heat quantities for the Crossley and Premier engines were—

	Crossley.	Premier.
Heat converted into work	27·8	33·65
Heat lost in cooling water	24·2	27·56
Heat lost in exhaust and radiation	48·0	38·79

There was no tar at all deposited from the gas issuing from the Mond producer; a very small quantity appeared in the sulphate of ammonia, and that collected from the washers, towers, and mains was too small to have any value. He gave full details of the trial of the Premier engine at Sandiacre works, mentioned by Rollason. He did not agree with Clerk's criticisms; when the Mond plant worked without sulphate recovery, the fuel for steam-

raising was less than with the Dowson plant; when worked with sulphate recovery, more steam was needed, but against this should be placed the value of the by-products. His estimate of the quantity of gas produced at Winnington had been borne out by the measurements at Sandiacre; Clerk was therefore in error in estimating the efficiency at 50 per cent. At Oberhausen, gas dynamos were regularly paralleled for polyphase working, and gave no trouble.

Communications.—**J. E. Dowson** criticised the figures given in Donkin's table of tests as being in many cases inaccurate. He gave a table of twenty-six tests on different engines working with his gas plant. In reply to Robinson's statement that the quality of Dowson gas was variable, he said that in a 110-b.h.p. plant, in five hours the maximum variation in the calorific value of the gas was 5 per cent. **G. C. Jones** dealt with the efficiency of the Mond plant in detail, and concluded that it was 70 per cent., instead of 84·1 per cent., as given by the author. **M. Münzel,** of the Gas Motoren Fabrik, Deutz, wrote that it was quite practicable to parallel polyphase machines, if the engine were governed by varying the gas admission, not by missing explosions. Electric ignition must be used. He gave indicator diagrams of a 1,200-b.h.p. Deutz engine using blast furnace gas. **J. D. Roots** suggested a method of compounding gas engines, and illustrated it by diagrams. **R. Threlfall** referred to the curve of h.p. lost in fluid resistance; assuming that the resistance in viscous flow is proportional to the speed, he could account for the quicker increase of resistance shown in the curve only by supposing that the viscosity of the gases increased; this would require their temperature to be raised from 20° to 140° C. in the inspiration. He thought it most important to ensure a thorough mixture of the gases by breaking them up into thin streams, as was done in the Premier engine. **B. H. Thwaite** showed by a diagram the effect on the calorific value of producer-gas, of additions of CO, C_2H_4, CH_4, and H; the effect produced by the latter three is so much greater than that produced by CO, that a producer-gas containing them in any quantity must be very variable in calorific value. Measured by volume the heat value of H is no greater than that of CO, and he considered that the ideal power-gas would contain 30 volumes per cent. of CO and 3 of H. The Author, in reply to the written communications, dealt with the various possible ways of considering the efficiency of a gas producer. G. H. B.

1568. *d'Equevilley Valve.* **E. Legrand.** (Locomotion Automobile, 8 pp. 233–235, April 11, 1901.)—This article describes a form of valve for explosion engines, having the exhaust and the admission valve in one piece of mechanism. The exhaust valve is of the usual cone-seated form, but has a large hollow stem. On the face of the exhaust valve a cone-seating is turned to receive the suction valve, the stem of which passes up inside the exhaust valve stem. A light spring pressing on a thimble at the top of the suction valve stem keeps this on its seat after a suction stroke has been completed. The exhaust-valve stem passes through a bored cylindrical guide in the cylinder head, and in it are apertures which are normally opposite to the admission pipe, opening into the cylindrical guide of the valve stem. The explosive mixture is thus able to pass through these apertures, down the exhaust-valve stem, and into the cylinder, when the excess of external pressure causes the suction valve to open. The exhaust valve is controlled by a strong spring and operated by any suitable form of cam action.

C. R. D'E.

AUTOMOBILISM.[1]

1569. *Novel Transmission and Control Gearing.* (Horseless Age, 8. pp. 29–, April 10, 1901.)—This article describes a new form of gearing for motor vehicles, the distinguishing feature of which lies in the fact that, in the variable speed portion of the mechanism, the power is transmitted partly by belt and partly by chain. In the vehicle illustrated the double cylinder horizontal engine is placed at the front of a rectangular tubular underframe, the crank-shaft being parallel to the length of the frame. A sprocket pinion on the back end of the crank-shaft drives by a single chain two sprocket wheels mounted on two counter-shafts parallel to the engine crank-shaft, and lying in the same horizontal plane. One of the sprocket wheels is fixed to its shaft, while the other, which is attached to an internal toothed drum, runs free. On the shaft having the fixed sprocket is keyed a stepped cone pulley, and on that carrying the loose sprocket is a similar stepped pulley running loose on the shaft. An open belt controlled by a striker transmits part of the engine power from the fixed to the loose pulley ; a part is also transmitted by the chain drive to the loose sprocket wheel. The power is delivered to the shaft carrying the loose sprocket and pulley through the internal toothed drum of the sprocket wheel, and through satellite pinions running on spindles fixed to the loose belt pulley, which engage with the internal toothed drum, and with a spur wheel keyed to the shaft carrying the loose drum and sprocket. The power is thus divided up between the belt and chain in a proportion which depends on the rate of rotation of the satellite pinions relative to the internal toothed drum. The whole power is transmitted through the fixed spur wheel and its shaft, and hence through a bevel gear to the differential cross-shaft, and finally by independent chain drive to the road wheels. The gear as illustrated gives four forward and two reverse speeds. C. R. D'E.

1570. *Dawson Car.* (Automotor Journal, 5. pp. 318–319, April, 1901.)—This article describes the vehicle to which has been fitted the Dawson self-starting and reversible petrol engine described in Abstract No. 1731 (1900). The engine is mounted near the front of the underframe, with its crank-shaft lying across the frame. The power is transmitted through a friction clutch and chain drive to a counter-shaft on which run loose three chain pinions, two of which are on one sleeve, while the other is independent. A claw clutch enables either the independent sprocket or the sprocket sleeve to be driven from the shaft. The independent sprocket pinion and one of the pinions on the sprocket sleeve are geared by chains to sprocket wheels running loose on the sleeve of the differential gear on the live rear axle. The other pinion on the sprocket sleeve drives an independent sprocket wheel mounted free on the differential sleeve. By means of a second claw clutch, controlled by the same lever as controls the clutch on the counter-shaft, either the sprocket-wheel sleeve, or the independent sprocket wheel may be caused to drive the live axle through the differential gear. Four speeds are thus obtained, forward or reverse, according to the rotation of the engine. Ignition in the engine is effected by a special design of rotatory magneto machine driven by a chain and epicyclic gear. The magneto supplies low-tension current to a single induction coil, there being a high-tension switch driven from the armature shaft, by means of which the secondary of the coil is coupled to each sparking plug in rotation. The epicyclic gear enables the angular position of the magneto armature to be varied relatively to the crank-shaft, and so enables the point of firing to be readily adjusted. C. R. D'E.

[1] Electric Automobiles are described in the section dealing with Electric Traction.

GENERAL ELECTRICAL ENGINEERING.

1571. *Rosenthal Accumulator.* (Elect. Rev. 48. pp. 580–581, April 5, 1901.)—The electrodes of this cell are of the pasted type, but particulars as to the preparation of the active materials are not given. The details of the support are shown in a dimensioned drawing. It consists of a very slight grid having all its surfaces covered by active material. The horizontal bars are of circular section and the vertical bars of diamond section. The specific gravity of the electrolyte falls from about 1·300 to 1·170 during a complete discharge. The feature of the cell is its large output for weight, a 24-lb. cell giving 20 amperes for eight hours down to a potential difference of 1·8 volts, and a total output of 13·1 watt-hours per lb. of complete cell. E. J. W.

1572. *Aron Two-Tariff Meter.* **H. Aron.** (Elektrotechn. Zeitschr. 22. pp. 381–382, May 2, 1901.)—In this instrument there are two counting trains alternately thrown into gear with the arbor of an ordinary meter, the number of revolutions of which is proportional to the number of units passed through the meter. The change-over is effected by means of an independent pendulum clock which is electrically wound and drives two wheels, each revolving once in twenty-four hours. These wheels are capable of moving axially, and are each rigidly connected to a sleeve having a circumferential groove, in which one arm of a lever engages, the other arm of which acts on one arm of a three-armed lever, the third arm of this lever being connected by a link to an oscillating frame carrying three gear-wheels, and effecting the actual change-over. The axial motion of the wheels above mentioned is obtained by providing the end of each corresponding sleeve with a V-shaped notch, adapted to engage with a tooth on a sleeve having an indicator arm adjustable round a dial divided into 24, springs forcing the wheels and sleeves against the corresponding teeth. By this means, when a notch reaches a tooth, the wheel and sleeve move axially and reverse the oscillating frame through the levers above mentioned. C. K. F.

1573. *Energy Meters.* **P. Janet.** (Soc. Int. Élect., Bull. 1. pp. 64–111, Feb., 1901.)—The author divides the various systems of meters into three classes : (1) Motor Meters, (2) Oscillating Meters, (3) Meters with Intermittent Integration.

In the first class are : (1) *Meters of the Thomson type. Thomson meter* for continuous currents. Improvements introduced into the latest model of this meter are: the brushes are movable about their axis of inertia, so as to be insensible to vibrations, and are made stirrup-shaped so as to ensure contact at two points on each brush ; the brushes and lower pivot can be examined without opening the case, which is hermetically sealed. Tests on a 10-ampere meter show a consumption of 2·77 watts on 100 volts, and 3·35 watts on 110 volts ; the starting watts are 0·7 per cent. of the maximum. In the alternate-current meter, Frager has introduced a correction for the lag in the shunt circuit by producing an equal lag in the series circuit ; this is accomplished by placing in the main coils a winding short-circuited on itself. The effect of this is to reduce the error, when indicating on low power-factors, to about half its value ; on a power-factor of 0·27, the error was 4 per cent.

ux meter by the Luxsche Industrie Werke. This differs from the Thomson meter only in the form of the armature, which consists of three flat coils with axes at 120° ; for the same torque this form is lighter than the ordinary form in the ratio 1 : 1·7. *Vulcain meter* [Abstract No. 1419 (1899)]. Tests of a 10-ampere meter showed a consumption of 2·01 watts at 100 volts, and 2·43 watts at 110 volts ; starting watts 0·4 per cent. of maximum. *Schuckert meter.* This differs from the Thomson only in having the position of the compound winding adjustable, for the purpose of regulating the friction compensation. The continuous-current meter for 150 amperes shows a consumption of 1 watts on 220 volts ; the alternate-current 10-ampere meter, 4 watts on 110 volts ; starting watts 0·8 per cent. of maximum watts. On power-factors of 0·5 and 0·07 the errors are, respectively, 4 per cent. and 17 per cent. *Perdrisat meter* by the Société Perdrisat, Blanc & Cie. This meter contains iron in the armature ; it is very simple and light, the 50-ampere size weighing only 1 kilos. *Peloux meter* [Abstract No. 1420 (1899)].

(2) *Rotary field meters.* The author describes in detail the principles on which this type of meter is based. The following are described : *Blathy meter. Hummel meter.* In this a lag of exactly 90° is produced in the pressure circuit by shunting the coil with a non-inductive resistance, and joining in series with these two coils an inductive resistance. *Helios meter. Raab meter*, by the Elektrizitäts-Aktiengesellschaft vormals Schuckert. In this the main, shunt, and damping fields all act on the same disc. A phase-lag of 90° is produced in the shunt circuit by winding two coils in parallel on two electromagnets ; one produces the main field, not quite 90° out of phase, the other, wound in opposition, is in series with a non-inductive resistance, and gives a weak field with small lag ; the two fields can be adjusted to give a resultant with a lag of exactly 90°. The 10-ampere meter takes 2·5 watts on 115 volts ; with a power-factor of 0·4, the error is only 3 per cent. *Hartmann and Braun's meter* [Abstract No. 724 (1900)]. *Batault meter*, by the Société Genevoise. In this the shunt electromagnet has a double core, with winding on one leg only, and a short-circuited winding embracing both legs ; by adjusting the resistance of the latter, the phase-lag is brought to exactly 90°.

(3) *Three-phase motor meters.* In a three-phase star circuit there are three expressions for the power, applicable in the case of unequally charged lines—

$$W = e_1 i_2 - e_2 i_1, \quad 2W = i_1(e_3 - e_2) + e_1(i_2 - i_3)$$

and—

$$3W = (i_1 - i_3)(e_3 - e_2) + (i_2 - i_3)(e_1 - e_3),$$

where, if V_1, V_2, V_3 be the potentials of the star ends, i_1, i_2, i_3 are the currents in the corresponding lines, and e_1, e_2, e_3 are equal, respectively, to $V_2 - V_3$, $V_3 - V_1$, $V_1 - V_2$. Each expression gives rise to a method of combining a field in phase with the current with one in quadrature with the pressure on each of two discs mounted on one axis. In the case of three-phase currents it is more easy than with alternating currents to produce a field in quadrature with the tension, as it can be done by producing a lag of less than 90 by a simple inductive coil. In the case of the first expression three methods have been patented respectively by Hummel, Siemens and Halske [Abstract No. 1764 (1899)], and Schuckert. The first consists in producing a field lagging 30° behind e_3 to represent e_1 in the term $e_1 i_2$, and similarly for the other term $e_2 i_1$; the second is to produce a field in phase with $V_1 - V_0$, which lags 90° behind $-e_1$, V_0 being the potential of the neutral point, which may be produced artificially in the meter by three similar coils ; the third is to produce a field lagging 60° behind $V_0 - V_2$, which then lags 90° behind e_1. The second

expression for power has been applied to a meter by Möllinger [Abstract No. 2312 (1900)], by creating a dissymmetric neutral point, so that $V_0 - V_3$ is 15° in advance of e_1, and $V_0 - V_1$ is 75° behind; coils producing lags of 75° behind these tensions then give fields in quadrature with $e_3 - e_2$ and e_1. The third expression is applied by producing fields lagging 60° behind e_2 and e_3 respectively. To produce the same torque the three systems absorb power in the respective ratios of 1 : 0·557 : 0·667.

Under the second head of Oscillating Meters, the author describes the *Aron meters*, applicable to continuous or alternating currents, also with double tariff (see preceding Abstract), to the charge and discharge of accumulators, to three-phase current, also with transformer, and to three-phase current with four wires [Abstract No. 1119 (1901)], and the *Allgemeine Elektrizitäts-Gesellschaft meters* [Abstract No. 1392 (1901)].

In the third class of Intermittent Integrating Meters are described *Brillié's meter, Brown and Routin's meter, Siemens' meter*, and *Holden's meter* [Abstract No. 2311 (1900)].

The Vulcain prepayment meter is described [Abstract No. 579 (1900)], and Brown and Routin's sliding scale meter [Abstract No. 1765 (1899)]. G. H. B.

1574. *Insulation on Cables.* **M. O'Gorman.** (Inst. Elect. Engin., Journ. 30. pp. 608–683; Discussion, pp. 684–700, May, 1901.)—A high insulation resistance is useful in feeders, chiefly to facilitate fault-finding; in distributors, where exposed terminals are frequent, it is of less importance. High insulation does not necessarily go together with high disruptive strength, and undue insistence on this quality precludes the use of many low-priced dielectrics which in other respects are suitable. In determining the thickness of dielectric required for a given disruptive strength, a factor of safety as high as 20 is sometimes used. A high factor is employed on account of the possibility of dirt, moisture, or bubbles finding their way into the dielectric; and, further, some dielectrics become polymerised, or give off gas, when subjected to an alternating e.m.f.

The author gives curves showing how rapidly the thickness of insulation must increase with increase of pressure, for a given maximum stress in the dielectric; the rate of fall of potential in the dielectric diminishes from the conductor outwards, and consequently the depth and cost of insulation increases far more rapidly than the voltage. For instance, allowing 20,000 volts per centimetre, a 37/14 cable would require 0·5 inch of insulation for 10,000 volts, and 1·89 inches for 20,000 volts.

The author proposes three methods for diminishing the thickness of insulation required, by utilising to the full its dielectric strength throughout its thickness. The first method is to make the dielectric strength of each layer of insulation proportional to the voltage gradient in that layer, by using materials of varying dielectric strength. Not much improvement can be looked for in this direction, as the strongest materials are commonly used throughout the insulation. The second method is to vary the specific conductivity of the different layers so as to produce a uniform rate of fall of potential. If this were done, the thickness of dielectric required for the 37/14 cable mentioned, at 20,000 volts, would be only 0·55 inch instead of 1·89 inches. When the insulation consists of paper impregnated with rosin oil, the conductivity of the inner layers can easily be increased by adding a very small percentage of linseed oil. The large effect of small impurities, however, and the temperature coefficient of the oils, destroy to some extent the value of this method, which, besides, is only useful for continuous

currents. The third method is to vary the specific capacity of the different layers, so that, considering the dielectric to be made up of a number of cylindrical condensers, the capacity of each is the same, in spite of the difference in their size. The author calls this "grading the capacity," and suggests various ways in which this varying specific capacity could be secured; for example, by the use of castor oil to increase the capacity of rosin oil. Formulæ are given for the calculation of the capacity of two-wire, three-wire, and other cables. He notes that many substances, notably oiled paper, empire cloth, and mica, have apparently a higher disruptive strength in small thicknesses than in large, and quotes Perry as explaining this by skin resistance.

The author then proceeds to deal with the cost of cables, which he works out as curves for several examples of transmission, on different systems and at different voltages, incidentally showing a 30 per cent. economy by grading, and showing when two single cables are cheaper than concentrics. The Board of Trade rule requiring 1/20 inch of insulation per 1,000 volts, weighs heavily on large cables, which are shown by curves to require less thickness of dielectric for a given voltage than small ones.

In appendices are given: (1) A table of the price, dielectric strength, specific capacity, and insulation resistance of a large number of dielectrics; (2) A table of Gray's results on the dielectric strength of various oils in layers of different thicknesses; (3) A table of current densities and losses in wires of different sizes at different frequencies; (4) A table giving capacity measurements of the three members of a three-wire cable before and after being laid up together; (5) Tables comparing the cost of cables on direct and one-, two-, and three-phase transmission, for delivering a given amount of power, on the basis of the same maximum voltage between any two conductors; (6) Two appendices on the capacity of cables; (7) A table of sizes and prices of three-phase, lead-covered, armoured cables, for different voltages. G. H. B.

1575. *Granite as an Insulator.* (Frank. Inst., Journ. 151. pp. 309–312, April, 1901. Report of a Committee.)—Granite chips are calcined, and powdered felspar and kaolin added with water to make a plastic mixture, and the moulded objects heated to 3,000° F. and glazed. The product absorbed 0·76 per cent. of water in a year. It crushed at 7,000 lbs. per square inch; showed a tensile strength 900 lbs. per square inch; and a sample of a size not stated had an insulation resistance of 8 megohms.
M. O'G.

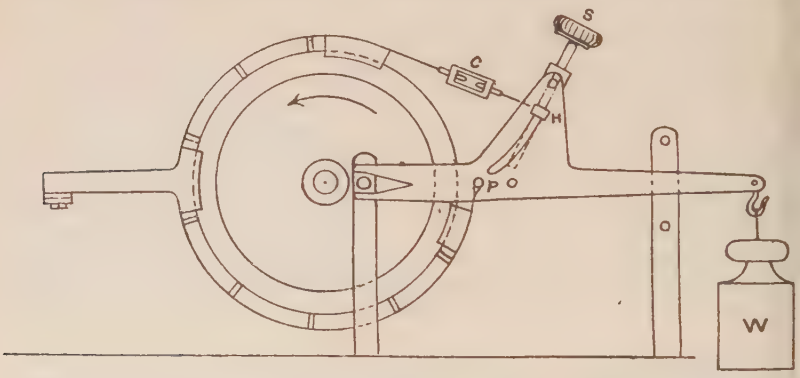
1576. *Electric Cranes.* (Zeitschr. Vereines Deutsch: Ing. 45. pp. 433–437, March 30, 1901.)—An account is given of a crane mounted on a truck travelling on rails of 1·92-metre gauge. The lifting rope, after passing over the pulley at the outer end of the jib, is guided down the centre of the hollow pillar on the top of which the jib is mounted. The jib is free to rotate. Current is taken from three overhead wires fed with three-phase currents. These wires rest freely at intervals on supports, from which they are lifted by the sliding contact-makers fixed on the crane. In order to carry the current down to the motors there are slip-rings and brushes above and also below the rotating part of the crane. Worm gearing is used to drive the rotating part; and, with the object of preventing damage to this non-reversible gearing by the momentum of the moving jib when the

current is switched off, the jib is not driven rigidly, but by friction. The truck is moved through worm and chain gearing.

A short description is also given of a three-phase crane for harbour use. The winding-drum is driven by a claw-coupling, which can be disconnected when lowering.

A number of drawings are included. W. H. E.

1577. *Adjustable Prony Brake.* **F. Hubert.** (Elektrotechn. Zeitschr. 22. pp. 339–341, April 18, 1901.)—The construction of the brake will be understood from the accompanying sketch. The brake pulley is provided with inwardly projecting flanges which provide a water-cooling arrangement. The brake band is fitted with the usual wooden blocks. One end of the band is attached to the point P of the brake lever, while the other end is connected to the coupling C, by means of which the brake band may be tightened. The other end of the coupling is attached to a cross-head H, which is capable of sliding along a curved slot, the adjustment being obtained by means of a screw S. There are thus two ways of tightening



the brake strap—one by means of C, the other by means of S. An upper and a lower stop limit the play of the lever during the time that the adjustment is being made. The end of the lever away from the weight W is slotted, and between the two prongs of the fork is a pin which is fixed to the frame of the machine. If the friction is too small, the upper prong bears against the pin. Should, on the other hand, the friction become too great, the lower prong is driven up against the pin, which now becomes the fulcrum of the lever, and any further tendency to carry round the brake is automatically checked, since it results in a slackening of the brake band.

A. H

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1578. *Characteristic of the Lead Accumulator and its Dependence on Electrode Construction.* **H. Wehrlin.** (Centralblatt Accumulatoren, 2. pp. 33–34, Feb. 1 and 49–53, Feb. 15, 1901.)—A paper on the same lines as that noticed in Abstract No. 218 (1901). The relation between e.m.f., capacity, and time of discharge is discussed and characteristic curves are given for different types of accumulators. N. I

1579. *Torpedoes Steered by Wireless Telegraphy.* (Scientific American, 8 pp. 101–102, Feb. 16, 1901.)—Description of some very successful experiments carried out in the English Channel with the torpedo invented by C. Varicas. J. E.-M

GENERATORS, MOTORS, AND TRANSFORMERS.

1580. *Direct-Current Generators.* **S. H. Short.** (Electrician, 46. p. 905, April 5, 1901. Abstract of a paper read before the Manchester Section of the I.E.E., March 26, 1901.)—Starting from the consideration that in the design of direct-current generators the tendency is towards an increase in the number of poles, and that there is, generally speaking, an approximation towards the modern type of alternator, the author proposes on these lines a method of standardising direct-driven dynamos. A "unit machine" is taken (bipolar) of which the electrical and magnetic data are calculated so as to give the best possible results. For a machine of double this output the author doubles the number of poles and the diameters of armature and commutator, and halves the speed, thus keeping all the other values—magnetic flux, current density, surface speed, &c.—the same as in the two-pole machine; for a machine of four times the output of the unit dynamo, the number of poles, the armature and commutator dimensions are again doubled and the speed again halved; and so on. In this way the same field and armature coils, brushes, holders, commutator bars, &c., can be used for any size of machine (working at the same voltage), thus diminishing the cost of manufacture. A table is given showing the different values of speed, output, armature and commutator diameters, and output per 100 revs. for different numbers of poles up to 30.

For the larger sizes of machine, the surface density of the current in the armature may be increased from 500 to 600 or 700 amperes per inch of width, thus lowering the number of poles, decreasing the diameter of the armature and increasing the speed. B. P. S.

1581. *Saturation of Armature Teeth.* **J. Fischer-Hinnen.** (Écl. Électr. 27. pp. 146–147, April 27, 1901.)—The author disagrees with Rothert [Abstract No. 1410 (1901)], who says that the saturation of the teeth should be as high as possible. He gives particulars of a number of machines which work with fixed brushes without sparking, with 7,300 to 15,000 lines per sq. cm. in the teeth, while Rothert suggests 23,000 to 25,000. He also says that the practice of winding several sections in one slot is well known, but seldom used because it causes sparking. R. B. R.

1582. *Weights of Generators, Motors, and Transformers.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 19. pp. 233–236, May 12, and 245–247, May 19, 1901. Paper read before the Elektrotechnische Verein, April 10, 1901.)—Sets of curves are given to show the relation between weight and output, the data having been obtained from fifteen of the largest works of different countries. The average results, expressed as kg. per kw., are condensed in the annexed table:—

	Full load output in kilowatts.			
	10	50	100	200
Generators	73	42	42	45
Direct-current motors	56	45	39	—
Induction motors	37	31	31	—
Transformers	36	26	24	22

W. H. E.

1583. *Predetermination of Drop in Alternators.* **G. Giles.** (Écl. Électr. 27. pp. 90–102, April 20, and 137–146, April 27, 1901.)—The author develops a method of calculating the drop of p.d. in alternators which is based mainly on the consideration of the reluctances of the air-gap and the leakage paths. Let the open-circuit characteristic of the alternator be given. If R_1 = reluctance of air-gap (corresponding to useful flux), R_2 = reluctance of leakage paths, Si = demagnetising ampere-turns due to armature when the power-factor is zero, and if we suppose that the total magnetic flux through the field core is the same as it was on open circuit; then in order to pass from any point on the open-circuit characteristic[1] to a corresponding point on the internal characteristic, we have to reduce the volts by an amount corresponding to the flux $\frac{4\pi}{10} \cdot \frac{Si}{R_1 + R_2}$, and to increase the ampere-turns by an amount $Si \frac{R_2}{R_1 + R_2}$. In order to find the external characteristic, we have further to subtract from the ordinate of the internal one an amount corresponding to the impedance drop in the armature. In order to obtain this latter correctly, the author uses an experimental armature coil of very fine wire superposed on the main coil and connected to a voltmeter. If the alternator is run on short-circuit with a current corresponding to the load current, the true impedance drop is easily found from the voltmeter reading and the number of turns in the exploring and main armature coils. The author next investigates the effect of damping-coils, and shows that if damping is perfect, then the armature back-turns are (power-factor = 0) given by $\frac{1}{2} SI_0$, where I_0 is the *maximum* value of the armature current (sine function assumed). If there are no damping-coils, then the e.m.f. of the alternator when loaded contains a third harmonic *even if the open-circuit e.m.f. is a pure sine wave.* The results are applicable to two- and three-phase machines, the back-armature turns of which are (power-factor = 0) given by SI_0 and $\frac{3}{2} SI_0$ respectively. Experimental results are given in support of the theory developed. A. H.

1584. *Testing Three-Phase Generators.* **M. Breslauer.** (Zeitschr. Elektrotechn., Wien, 19. pp. 185–187; Discussion, p. 187, April 14, 1901.)—A complete test of a large three-phase generator is frequently attended with difficulties, on account of having to provide the necessary large amount of power, and the three equal non-inductive load resistances. On a non-inductive load, which is the load generally employed in carrying out such a test, the drop from no load to full load should not exceed 3 per cent. in good machines of moderate output, and should not in any case be greater than 6 per cent. A very good estimate of the qualities of a machine may, however, be arrived at without actually running the machine at full load, by making use of the open-circuit (exciting current and voltage) and short-circuit (exciting current and armature current on short-circuit) characteristics. In order to find the load characteristic of the machine under constant excitation (the load being non-inductive), a right-angled triangle is constructed whose hypotenuse is equal to the constant exciting current, and one of whose sides is equal to the exciting current required to produce the given load current on short-circuit. The point on the open-circuit characteristic corresponding

[1] The *open-circuit* characteristic connects field-ampere-turns with open-circuit e.m.f., the *internal characteristic* connects them with e.m.f. corresponding to a given armature current and power-factor, and the *external* characteristic with p.d.

to an exciting current equal to the remaining side of the right-angled triangle then gives the terminal p.d. at that load. The author tested this theoretical method on a machine giving very bad regulation (and therefore very suitable for the purpose), and found practically perfect agreement between theory and experiment. A. H.

1585. *Design of Rotary Converters.* **H. S. Meyer.** (Elektrotechn. Zeitschr. 22. pp. 295–299, April 4, 1901.)—The author first deals with armature reaction and heating. Formulæ are given for the armature reaction corresponding to a power-factor of unity. Assuming a sine wave of current and a power-factor of unity, the output of a given machine when used as a three-phase converter is 1·34 times its output as a continuous-current generator. The various steps in working out a design are next dealt with in the following order: (*a*) The output, frequency, and voltage are given; the author states that the most favourable frequencies, from the designer's point of view, are from 25 to 30, that 30 to 40 are still admissible values (and in the case of small machines up to 50), but that with higher frequencies troubles are experienced on account of sparking. (*b*) The number of poles, and with it the revs. per min., are found by allowing a current not exceeding 300 amperes per brush bar. (*c*) The diameter is determined by allowing a peripheral velocity of not less than 23 metres per sec. (to secure good ventilation), and not more than 38 metres per sec.; further, the quotient of the diameter by the number of poles should not be less than 10 cm. (*d*) As regards armature reaction, since this is less in converters than in continuous-current machines, the full-load armature ampere-turns per pole may in general be assumed equal to, or greater than, the field-ampere-turns per pole at no load. (*e*) The voltage per commutator segment should lie between 10 and 16 volts. On the assumption of two commutator segments per slot, this immediately gives the number of slots in the armature core. This number should be so chosen as to make it divisible by the product of the number of poles into the number of phases. (*f*) On account of the smaller heating as compared with continuous-current machines, a current-density (taking the full-load continuous current) of from 450 to 600 amperes per sq. cm. may be allowed in the armature conductors. (*g*) The slots should be shallow and preferably open, or only partially closed. The armature winding is always a parallel winding. (*h*) The length of the polar arc should be from 70 to 80 per cent. of the polar pitch. The leakage coefficient would be about 1·2. (*i*) The induction may range from 6,000 to 9,000 in the armature core, from 16,000 to 20,000 in the teeth, from 7,000 to 9,000 in the air-gap, from 12,000 to 14,000 in the pole-piece, and in the yoke it may be 5,000 for cast-iron and 9,000 for wrought-iron. (*k*) The length of the armature core is easily found from the length of the pole-arc, the permissible induction and the total magnetic flux per pole; ventilating apertures should be provided in the armature core about every 12 cm. (*l*) The pole-shoes should be shaped so that the air-gap increases in length close to the edge of the pole-piece, in order to widen the zone of sparkless commutation. (*m*) The peripheral velocity of the commutator should be high, up to 25 metres per sec. The thickness of the *micanite* insulation between segments should be from 1 to 1·25 mm. The brush thickness varies from $2\frac{1}{2}$ to $3\frac{1}{2}$ commutator segments, and the total length of commutator is obtained by assuming a current-density of 4·5 to 6·5 amperes per sq. cm. of contact area (carbon brushes). Two devices are described for securing even wear of the commutator by giving the armature an axial oscillation. In one of these, an annular electromagnet whose circuit is periodically closed is attached to the

end of the bearing, and pulls the armature shaft in an axial direction, while in the other an inclined end-plate is employed, the end-plate and shaft being provided with a circular groove in which runs a ball. The author finally considers the efficiency and hunting of rotary converters. A. H.

1586. *Haselwander's Single-phase Induction Motor.* **H. Michel.** (Zeitschr. Elektrotechn., Wien, 19. pp. 169–171, April 7, 1901.)—The construction of this motor will be understood by reference to the accompanying sketches. Fig. 1 is a diagram of the ordinary form of single-phase motor, EE denoting the two stator coils, which produce a field indicated by the dotted straight lines; i_2, i_2, m_1 and m_2 are the rotor coils, which are connected to two short-circuiting rings (dotted circles), s_1 and s_2. In the position of the rotor shown in the figure, i_1 and i_2 act as sources of secondary e.m.f., but the motor coils m_1 and m_2 receive no appreciable current, since practically the whole of the current

FIG. 1.

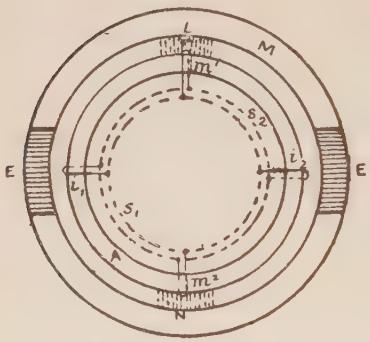
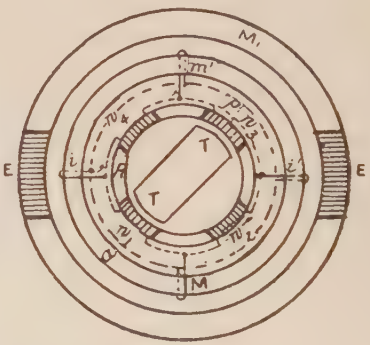


FIG. 2.



flows round the copper rings. If, however, the arrangement devised by Haselwander, and illustrated in Fig. 2, be adopted, the motor becomes capable of exerting a torque when at rest. One end of each coil is connected to a copper ring. The other ends of the coils are connected with the interposition of choking coils w. The impedance of each choking coil is, for a certain position of the coil, greatly increased by a fixed inductor TT. The result is that the coil m will, in the position shown, receive current from i', and the coil m current from i, the coils w_1 and w_3 exerting a powerful throttling action. Various modifications of this principle are illustrated. A. H.

1587. *Effect of Irregularities in the Field of an Induction Motor.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 22. pp. 335–339, April 18, 1901.)—It has been customary, in dealing with induction motors, to assume that the space-distribution of the magnetic flux in such motors follows the simple sine law. Certain facts, however, such as the dependence of the starting torque and short-circuit current on the position of the rotor relatively to the stator, can only be accounted for by irregularities in the distribution of the magnetic flux. The author makes a detailed study of these irregularities, and supposes that the actual motor is replaced by a number of ideal motors whose stator windings are coupled in series, and are so arranged that the consecutive stator windings produce fields whose polarity corresponds to the various simple harmonic components of the actually existing field. The rotor windings are

also coupled in series with each other, and all the rotors are supposed to be mounted on the same shaft. The author comes to the conclusion that a rotor whose power-factor is very high will not start even when unloaded, and will show dead points; and that in all calculations based on the assumption of sine waves of p.d. and current, and having reference to a speed not far removed from that of synchronism, the assumption of a single simple sine field (in space) furnishes sufficiently accurate results. A. H.

1588. *Starting Device for Single-phase Induction Motor.* **M. Osnos.** (Zeitschr. Elektrotechn., Wien, 19. pp. 196–199, April 21, 1901.)—The author suggests a starting device which consists essentially of an arrangement for disconnecting a portion of the ordinary stator winding of the motor and closing it through an external non-inductive resistance. The portion of the winding so disconnected acts like the secondary of a transformer, the result being the production of an auxiliary field which differs in direction and phase from the main field. When the motor has run up to speed, the short-circuited portion of the winding is reintroduced into the circuit of the main winding, and the motor goes on running as a simple single-phase motor. The author points out that such an arrangement involves no additional special winding, but only a suitably designed starting switch and non-inductive resistance. The method has not, however, been tested practically. A. H.

1589. *Diagrams for Special Cases of General Transformer.* **K. Kuhlmann.** (Elektrotechn. Zeitschr. 22. pp. 341–344, April 18, 1901.)—The author deals graphically with the following problems: (1) That of the general transformer without any inductive resistances in the secondary circuit (induction motor), the primary p.d. being supposed constant. He shows that the locus of the extremity of the primary current vector is a circle, and gives an account of experiments carried out with an induction motor, which show remarkably close agreement with the theoretical values deduced from the diagram corresponding to this motor. (2) That of the general transformer, the secondary power-factor being constant. In this case also the extremity of the primary current-vector traces out a circle. The same result is next shown to hold for the most general case, the secondary inductance being assumed constant, and the power-factor variable. A. H.

REFERENCES.

1590. *Starting Resistances for Induction Motors.* **O. Bergmann.** (Zeitschr. Elektrotechn., Wien, 19. pp. 137–138, March 24, 1901.)—A brief contribution dealing with the problem of designing a starting resistance for a three-phase induction motor in such a manner as to enable the torque of the motor to be kept approximately constant. A. H.

1591. *Tramway Motors.* **S. H. Short.** (Elect. Rev. 48. pp. 545–547, March 29, and 589–593, April 5, 1901.)—Two articles, illustrated by several process blocks, describing generally the construction of tramway motors.

1592. *Induction Motor Diagram.* **J. K. Sumec.** (Zeitschr. Elektrotechn., Wien, 19. pp. 177–180, April 14; and 193–196, April 21, 1901.)—This is a very thorough treatment of the induction motor problem, the resistance-drop in the stator windings being taken into account. The locus of the primary-current vector is shown to be a circle, while the heat losses, the output, torque, slip and efficiency are all capable of being represented in the diagram by means of straight lines. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1593. *Efficiencies of Small Lighting Plants.* **A. W. Richter** and **B. V. Swenson.** (West. Soc. Engin., Journ. 5. pp. 471–484; Discussion, pp. 484–487, 1900.)—This paper embodies the results of detailed tests made upon four small electric lighting plants, of powers ranging from 50 to 700 i.h.p. Three of these use belt-driving, and several of them supply power for pumping or traction in addition to the lighting load. The coal used per i.h.p.-hour varied from 2·58 to 9·1 lbs.; the average efficiency (e.h.p. : i.h.p.) was from 53·2 to 74·6 per cent., and the thermal efficiency of the engines was 6·15 to 11·20 per cent. Full details of the results are given, with diagrams showing the distribution of the losses through the plant. The proportion of the whole energy of the coal which was delivered at the switchboard ranged from 1·87 to 5·69 per cent.

The discussion turned upon details of the tests. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1594. *Manchester Electricity Works.* (Electrician, 46. pp. 926–932, April 12, 1901.)—This article gives an account of the changes which are in progress at Manchester. A large power station is being erected at Bloom Street, which is to have a capacity of 14,000 i.h.p. This is close to the Dickinson Street station, which has a capacity of 12,000 i.h.p. A third generating station is to be erected at Stuart Street, having eventually 50,000 i.h.p. installed. Continuous current is to be supplied to the consumer throughout; in the central area there will be a five-wire system, and in the outer area a three-wire system; in both cases the pressure between the outers will be 400 volts. At Stuart Street three-phase current will be generated at 6,500 volts, and be transmitted to a large number of substations, about a mile apart, where, by means of static transformers and rotary converters, it will be distributed as continuous current. A heavy demand is anticipated from the tramways, and as the result of spacing the substations at short intervals it is hoped that the maximum drop in the rails will be kept below 1½ volts. At Bloom Street the engine-room will contain four steam dynamos, running at 75 r.p.m., and giving about 1,900 kw., either at 440 volts as shunt machines, or at 500 volts as compound-wound machines, the higher voltage being intended for the trams. The boiler-house will contain eleven Babcock boilers, each fitted with a superheater, and having a heating surface of 5,140 square feet. The economisers are to be fitted above the boilers, each boiler having its own economiser. The main flues will therefore discharge into the chimney at a level of 30 feet above the ground. The chimney is octagonal, 230 feet high and 12 feet across the octagon inside. This station is not yet complete, though it had been expected that it would have been in working order before last winter. No work appears as yet to have been done on the Stuart Street station, but mains have already been laid throughout the district. There will be 30 cables leaving this station, owing to the requirements of the Board of Trade that no cable shall carry more than 1,000 kw. All three-phase feeders are of the same size, and are made up of three

conductors, each 0·15 square inch in sectional area; they are lead-covered and armoured, and are laid in cast-iron troughing on the solid system. The troughs are 9 feet in length, and contain either two or three cables. One of the bridges in every length of troughing is of malleable iron, and is secured by set screws to the troughing; an iron clamp is then placed over the cable, and connected to the bridge so as to secure contact between the armouring and the length of troughing. In this way the troughing is made electrically continuous. The joint boxes are of special design, of which drawings are given. The mains were tested with a pressure of 13,000 volts between each conductor and earth, the other conductors and the armouring being connected to earth during the test.

A certain number of 100-kw. rotary converters have already been installed and put to work, though the method of working is intended as a purely temporary expedient. The system adopted is, however, interesting, as also is the method of testing. Continuous current at 440 volts is supplied to the rotaries, and by them converted to three-phase current at about 260 volts. This pressure is raised by static transformers to 5,000 volts, and the power is then transmitted to a distant substation, where, by an inversion of the preceding process, it is reconverted to continuous current. At the substations the step-down static transformers have connections made to ten different points on the low-pressure winding, and these connections are brought out to terminals. By this means the regulation of the three-wire network is done without the aid of any balancers, the static transformers having their windings connected in a star, the common junction being connected to the middle wire of the distributing system. The rotary therefore supplies current direct across the outers. The testing was carried out as follows. Continuous current was supplied to a rotary converter, and by it converted to three-phase current; this was stepped up by one transformer and down by another, and then passed through a second rotary, the continuous current given out being absorbed by a resistance. Under these conditions the efficiency was determined by comparing the inputs and outputs on the continuous-current sides, and in some cases this efficiency turned out as high as 81 per cent. at full load. Very similar results were given by a modification of the Hopkinson test, the continuous current from the second rotary being returned to the first. Figures are given showing the efficiency of the combinations at various loads.

The article contains drawings showing the connections on the switchboard for the three-phase transforming plant, the design of a disconnecting box for three-phase cables, the arrangements in the boiler-house to allow for expansion in the steam-pipes, and also a plan of the district to be dealt with by the various substations. W. H. S.

1595. *Power Station of the Union Traction Company, Indiana.* (Street Rly. Rev. 11. pp. 203–212, April, 1901.)—System: Power generated by three-phase alternators, transformed up to high-pressure, and transmitted to substations equipped with step-down transformers and rotary converters. The boiler-room contains six Babcock boilers, each having a heating surface of 4,000 square feet, and working at a pressure of 155 lbs. per square inch. Each boiler is fitted with a firebrick arch 3 feet deep at the front end, forming a combustion chamber.

The feed water is heated by a Stillwell-Bierce exhaust steam heater, receiving the exhaust from the auxiliary engines, and capable of heating 120,000 lbs. of water per hour from 60° F. to 212° F.

Coal is stored in elevated bunkers, from which it is fed by spouts to the boilers, and is fired by Babcock chain grate mechanical stokers. A complete coal and ash conveying equipment is provided.

The engine-room contains three cross-compound Corliss automatic cut-off condensing engines, each having cylinders 26 and 50 inches diameter, stroke 48 inches, and capable of giving a maximum of 2,000 i.h.p. at a speed of 100 r.p.m. There is a separate jet condenser to each set.

Each engine drives directly a three-phase Westinghouse alternator, giving 1,600 amperes in each phase at a pressure of 400 volts, with a power-factor of 90 per cent., at a frequency of 3,200 cycles per minute. The alternators can be excited by a motor-dynamo, a steam-driven dynamo, or a storage battery.

The current is transformed up to 15,500 volts by means of fifteen 250-kw. transformers, and is transmitted by four overhead feeder lines to eight substations, equipped with step-down transformers and rotary converters. There are also three converters in the main station.

There is a storage battery of 264 Chloride cells in the main station, rated at 211 kw. for one hour, and each of the substations is equipped with a similar battery of either 168 kw. or 84 kw. The operation of these batteries has proved highly successful and economical.

A portable substation, consisting of a rotary converter, transformers, &c., mounted on a car, is kept in readiness for hauling to any of the substations in case of emergency.

The track is equipped on the direct-current overhead trolley system, and is in all 163 miles in length, including long stretches between several large towns. For the interurban service 25 new cars have recently been provided, each seating 52 passengers and having a baggage compartment. Each car is mounted on a Baldwin motor truck, equipped with two 150-h.p. Westinghouse motors, and a trailer truck, and is intended to run at a speed of 42 miles per hour under favourable conditions.

The description of the power station and of the substations is fully illustrated. A. H. A.

1596. *Electrical Plant in an Engineering Shop.* **W. Philippi.** (Elektrotechn. Zeitschr. 22. pp. 2-9, Jan. 3, 1901.)—A description of the power and lighting installation at the Sächsische Maschinen-Fabrik of Chemnitz. Three-phase current at 120 volts was chosen for the lighting network, partly because 3 arcs could then run in series and partly to have the advantage of the town supply as a reserve. For power purpose 500 volts direct current was installed.

The boiler-house is built for 4, and contains 2 water-tube boilers, Gehre system, concerning which the chief data are as follows: Heating surface 200 sq. m.; pressure, 12 atmospheres; 108 water tubes, outside diameter, 108 mm.; 12 superheating tubes (to ensure dry steam), 95 mm. outside diameter: width of drum, 1,500 mm.; length of drum, 6,850 mm. A specially shaped fire-bridge, together with a "Leach" mechanical stoking apparatus, secures smokelessness, with a saving of 10 per cent. in coal and an increase of 25 per cent. in duty, as compared with hand firing. Coal-handling plant is provided.

The steam plant comprises two 500-h.p. sets with room for a third. The engines are triple condensing, rated at 575 i.h.p. or 500 b.h.p., and a maximum of 650 b.h.p. at 150 r.p.m., with steam at 11 atmospheres; cut-off in the h.p. cylinder at normal load is at 0·3 of stroke; steam consumption at norma

load, 5·8 kg. per i.h.p. per hour; cylinder diameters, 425 mm., 665 mm., and 1,060 mm., by 600 mm. stroke.

The three-phase generators are rated at 725 amperes at 500 volts on non-inductive load, and carry their own direct-connected exciters. There are at present some 60 motors, aggregating 1,700 h.p., the largest being 105 h.p.

Allowing 5 per cent. for interest on the whole installation, 5 per cent. depreciation on plant inside the generating house and 3·5 per cent. on outside plant, &c., the costs per h.p.-hour are 4 pfennig measured at the generators, or about 5·5 pfennig, measured at the motors. E. H. C.-H.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1597. *Lorain Steel Company's (Brown's) Surface Contact System.* (Tram. Rly. World, 10. pp. 141–145, March, 1901.)—Contact boxes are spaced 8 to 16 feet apart and are connected on to the feeder conduits by a Y-casting, the maximum depth required being 15 inches. The base of the contact box is preferably made of "reconstructed granite," a material as durable as granite and as good an insulator as the best porcelain. In a recess in this base is an hermetically sealed vulcasbeston cup containing the circuit closer. At the top of the cup is a carbon contact connected to the surface knob. The corresponding contact is carried on a soft-iron plate, $4\frac{3}{4} \times 2 \times \frac{1}{16}$ inches, which is normally resting on a ledge at the bottom of the cup and is connected to the feeder through a thin, hard-rolled copper strip folded on itself. The top of the box consists of hard non-magnetic manganese steel in the centre where the contact-shoe rubs, and iron on either side. The car carries a shoe flanked by magnets whose magnetic circuit is closed through the soft-iron plate carrying the carbon contact, which is thus connected to the surface knob. The poles of the magnets on the car are composed of a number of separate plates rigidly connected together with wooden distance pieces—an arrangement which is claimed to give an equal magnetic field through the length of the magnet and to avoid danger of short-circuiting when crossing other tracks. The magnets are compound wound, one winding being in series with the motors, and the other across the 500 volts. Six cells are carried for the initial pick-up. With a magnet system 4 feet longer than the collector shoe, the time element for the operation of the circuit closers permits a speed of 20 miles per hour. A very satisfactory form of shoe is composed of a contact strip of non-magnetic material, a piece of heavy rubber and linen hose, and a wooden support, all clamped together. E. H. C.-H.

1598. *Soldered Bonds, &c., at Seattle, U.S.A.* (Street Rly. Journ. 17. pp. 270–275, April, 1901.)—Soldered leaf bonds are now the standard in the Seattle Electric Company. Seven layers of sheet copper, together 0·25 inch thick by 1 inch wide are tinned for $1\frac{1}{2}$ inches at each end and bent into U-shape in the middle. Holes are bored in each end, so that molten solder will run to the centre as well as round the edges. In new construction with 72-lb. Shanghai T-rail, these bonds are sweated under the base, the fished rails being inverted for the purpose. The rail is heated with a powerful gasoline torch; common soldering acid is used, the flow of solder being assisted by a soldering iron. When the bond is standing in a pool of solder, it is held down tight and water applied to wash off the acid and cool the joint. The essential for

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

success is plenty of heat quickly applied. A stone is put between the ends to prevent the heat at one end melting the joint at the other. Two men can solder both ends of a bond in five minutes. In paved streets a tin box is slipped over the bond before concrete is put round it.

On single lines the Seattle Company use a system of block signalling with lamps operated by the motor man pulling cords hanging from switches attached to the trolley-wire. On the steepest routes, cable cars alone are possible. On others, a counterweight system is used at certain grades. Details of conduit, tunnel, grip, &c., are given. E. H. C.-H.

1599. *Electric Vehicles for Public Service.* **K. Simons.** (Elektrotechn. Zeitschr. 22. pp. 351–354, April 18, 1901.—Paper read before the Elektrotechnische Gesellschaft, Cologne, Dec. 19, 1900.)—The author considers the various types of electric automobiles, the performance of batteries, efficiencies of motors, cost of vehicles, &c., and concludes that electric cabs cannot afford to stand idle on ranks, but must be concentrated in depôts, like fire engines, so that inspection and repairs can be constantly done by the unemployed drivers. E. H. C.-H.

1600. *Magnetic Field Produced by Electric Tramways.* **A. W. Rücker.** (Phil. Mag. 1. pp. 423–431, April, 1901. Paper read before the Physical Society of London.)—In the case of a straight line of tramway the magnetic field at any point due to the current in the trolley-wire can be easily calculated, but that due to the return current is somewhat uncertain. In the present paper the return current is treated in two different ways. In the first it is treated as if part of the current was carried back by an insulated rail while the remainder returned through the earth (supposed to have uniform conductivity), the earth current being treated as a problem in conduction between a source and a sink. The current in the rail is called the "*equivalent uniform current*" and is of course different from the "*mean*" current. Experiments made on a line at Stockton, two miles long, gave results which would agree with those given by a current in the rails equal to 84 per cent. of the whole, the remaining 16 per cent. returning by the earth. In the second method it is assumed that the leakage at each point of the rail is proportional to the difference of potential between that point and the earth. The problem is then similar to that of a Fourier bar. This problem is dealt with mathematically at some length. When applied to the Stockton experiments it gives a "*mean*" current in the rails of 86·7 to 87·4 per cent. and a minimum current in the rail of 80·6 to 81·4 per cent. J. B. H.

1601. *Practical Application of the Theory of Magnetic Disturbance by Earth Currents.* **R. T. Glazebrook.** (Phil. Mag. 1. pp. 432–442, April, 1901. Paper read before the Physical Society of London.)—This paper contains some applications of Rücker's theory. In similar circuits similarly placed, the vertical force varies as the linear dimensions of the circuit multiplied by the current. If the same number of cars per mile run on all circuits, the currents are proportional to the linear dimensions. Hence the vertical force would then vary as the square of the linear dimensions.

The results of Rücker's Stockton experiments [see preceding Abstract] are compared with those given by Parry [Abstract No. 2514 (1900)]. In the former the ratio of the external conductivity to the internal conductivity in the Fourier bar problem ($\mu = h/k$) is 0·64, while in the latter it is 0·42.

The vertical force at a point situated at a perpendicular distance y from the middle of a line of length a, is—

$$F_z = \frac{0{\cdot}62}{4} \lambda\mu^2 \frac{a^4}{y} \frac{1}{\sqrt{4y^2 + a^2}} \times 10^{-5},$$

where λ is the ratio of the current to the length of line—

$$I = \lambda a.$$

The total leakage in length a—

$$= \frac{h\nu a^3}{8} = \frac{\lambda\mu^2 a^3}{8}$$

where ν is the potential-difference between two points one mile apart. Suppose we wish to find the connection between the length of the line and its distance from the observatory, so that when its effect is a maximum it may be less than a given quantity, δ say. Calculate in absolute units the leakage in a rail one mile long when carrying the maximum current required to drive the maximum number of cars in the mile. Let the result be L c.g.s. units of current. Then a must not exceed the value given by the equation—

$$1{\cdot}24 \times L \times \frac{a^4}{y} \frac{1}{\sqrt{(a^2 + 4y^2)}} 10^{-5} = \delta.$$

Two miles of track carrying a current of 300 amperes with a potential-difference of 7 volts between the ends might produce a vertical magnetic force of $0{\cdot}5 \times 10^{-5}$ units on an observatory at a distance of three miles. J. B. H.

ELECTRIC LAMPS AND LIGHTING.

1602. *Street Lighting in St. Louis.* **H. H. Humphrey.** (West. Electn. 28. pp. 180–181, March 16, 1901. Abstract of a paper read before the Engineers' Club of St. Louis, Nov. 21, 1900.)—The lighting is by six pairs of 110-light series arc dynamos, each light requiring 500 watts. Each pair of arc machines is driven by a 200-h.p., direct-current, 500-volt motor. Five sets of machines are able to supply the present city lights, leaving one set as a reserve. The average efficiency of transformation of the plant is 80½ per cent.; probably one-third of the 19½ per cent. loss could have been saved by driving the generators direct from the engine, but it is considered that the practical advantages of the method employed more than compensate for the extra loss in efficiency. The street lamps are direct-current, series, enclosed-arcs suspended on iron poles; the candle-power of these lamps is 16 per cent. greater than that of the alternating series enclosed-arc lamp for an equal expenditure of energy at the arc. There are three underground 105-lamp and seven overhead 90-lamp circuits. Some trouble was encountered owing to the static discharge from the underground cables, which resulted in the short-circuiting of arc-lamps through the insulation at the top of the enclosing globe. This evil was satisfactorily remedied by soldering together the lead sheathing of the cables at the manholes and switchboard, and attaching to the copper of each circuit at the switchboard a rotating static-discharger, consisting of a Leyden-jar with its outer coating earthed. The city contract includes, besides the arc-lights, a number of incandescent lights throughout the city; these are supplied from the company's regular three-wire 235–470-volt mains, and are turned on and off by switches actuated by the currents in the arc-light circuits, each switch controlling the incandescent lamps in its neighbourhood. J. H.

TELEGRAPHY AND TELEPHONY.

1603. *Cable Recorder.* **C. Jaulin.** (Journ. Télégraph. 25. pp. 173–175, June, 1901.)—An invention of M. Ader. The currents pass through a fine, long, copper wire, diameter 0·02 mm., weighing 1 mg., placed vertically between the poles of a strong permanent magnet. The wire undergoes displacement at its centre, on one side or the other according to the direction of the current, its vertical position of rest being assured by the wire being under tension. This force can be regulated by a stretched silk thread acted upon by a weight. The wire is in a very narrow space between poles of not more than 0·5 mm. in breadth. The sensibility of this receiver is such that signals are produced by a current of $\frac{1}{3}$ of a micro-ampere. It is actuated by feebler currents and more quickly than the siphon recorder. A light shines through an orifice in one polar piece on to the middle of the wire, and through a slit in the other polar piece, the shadow of the wire being thrown upon sensitised paper. To emphasise this shadow, the wire has a little sheath of very light feather pith. A small motor actuates the tape, and there are baths within a cabinet for developing, washing, and fixing the photographic trace. The inventor claims, by trial made on an Atlantic cable in 1896, that transmission was 60 per cent. quicker than with the siphon recorder. E. O. W.

1604. *Telephony on Telegraph Lines.* **O. Canter.** (Elektrotechn. Zeitschr. 22. p. 302, April 4, 1901.)—The secondary of the microphone induction-coil is connected in the telegraph circuit, between the telegraph apparatus and the line; from between the induction coil and telegraph apparatus, a connection is made to earth through a condenser of about 0·2 microfarad capacity. The telephone apparatus is thus entirely independent of the telegraph line, and the condenser prevents the telegraph currents from affecting the telephone The author describes some suitable forms of condenser made in the shape of a coil, either by winding two parallel wires on a bobbin or by rolling up strips of tin-foil and paper. G. H. B.

REFERENCES.

1605. *Wireless Telegraphy.* **M. Lamotte.** (Écl. Électr. 26. pp. 432–444, March 23, 1901.)—A good *résumé* of recent papers on this subject. J. E.-M.

1606. *Party-Line Telephone System.* **E. Pierard.** (Soc. Belge Élect., Bull. 17. pp. 506–510, 1900.)—The author describes and illustrates connections for numerous stations on one metallic circuit line—in series and in parallel; also a method of using one line for calling, the other for speaking. J. E. K.

1607. *Automatic Telephone Exchange at New Bedford, Mass.* **A. D. Adams.** (Elect. World and Engineer, 37. pp. 225–228, Feb. 9, 1901.)—The author describes the automatic exchange, fitted with Strowger apparatus. J. E. K.

1608. *Telephone Cable under River.* (Elect. World and Engineer, 37. pp 436–438, March 16, 1901.)—This article describes construction of shafts and tunnel for carrying cables under Milwaukee River. Plans and illustrations are given. J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

SEPTEMBER 1901.

GENERAL PHYSICS.

1609. *Specific Gravities of very small Masses of Solids.* **G. Guglielmo.** (N. Cimento, 1. pp. 290–294, April, 1901 ; Accad. Lincei, Atti, 9. 2. ser. 5. fasc. 8.)—Description of apparatus : A kind of submerged float, capable of rotating round an axis and weighted with the body to be examined. This body, being practically used as a rider, may be very small. The results are extremely accurate, especially when observations are made in two liquids of known specific gravity. A. D.

1610. *Influence of Heat on Elasticity.* **M. Rudeloff.** (Tech. Versuch. Berlin, Mitth. 18. 6. pp. 293–314, 1900.)—Exhaustive research was made on various metals (cast iron, cast steel, beaten bronze, and lead), by bending and stretching rods at various temperatures. The influence of the method of casting was also carefully noticed. Stresses were put on up to and including the breaking load. Curves and tables are given showing that most metals are as strong for small loads at fairly high temperatures as at low temperatures ; but for greater loads they are much weaker. The author has constructed models in three dimensions (like those by Willard Gibbs in Thermodynamics), the axes being in this case (1) temperature ; (2) load per square mm. ; (3) yielding.

The research, which was conducted at the Institute in Berlin for testing metals, is purely experimental. But the curves and diagram speak for themselves. P. E. S.

1611. *Influence of Previous Physical Changes on Elasticity.* **M. Rudeloff.** (Tech. Versuch. Berlin, Mitth. Ergänzungsheft, 1. pp. 1–76, 1901.)—A very lengthy report on the elasticity of various metals, amongst which are copper, steel of various kinds, soft iron, delta-metal, manganese bronze, &c. The main object seems to have been to find the influence which bending and straightening, stretching and compressing, have on the elasticity of materials. Thus repeated stretching on the same specimen was made with intermediate examination of elasticity. Tables and curves are given in great quantity. There was also research on other points, such as (1) the influence of annealing, (2) the relation of stress to strain at various temperatures. Other researches by the same author on this subject are referred to in the preceding Abstract, and in No. 774 (1901). P. E. S.

1612. *Influence of Capillarity on the Outflow of Liquids.* **C. Christiansen.** (Ann. d. Physik, 5. 2. pp. 436–447, May 29, 1901. Translated from "Oversigt d. Kgl. Videnskabernes Selskabj Forhandlingär," No. 1, 1901.)—This is a description of interesting experiments on the efflux of liquids as influenced by capillarity, friction, &c. It is found that when the stream is changing from drops to a continuous column the rate of flow is a minimum. The influence of capillarity is shown by placing the nozzle of the discharge tube under water, when it is found that the rate of discharge is faster than in air for a small head of the liquid. It is also shown by placing the tube above ether, when the velocity of efflux is increased. The result of polarising the surfaces of separation is also studied. R. S. W.

1613. *Determination of Surface Tension at the Interface of Two Liquids.* **F. R. Watson.** (Phys. Rev. 12. pp. 257–278, May, 1901.)—A description of methods and results, the methods being based upon Rayleigh's ripple-wave method, with improvements. A. D.

1614. *Relation between the Viscosity-Parameter and other Physical Constants.* **A. Batschinski.** (Zeitschr. Phys. Chem. 37. pp. 214–216, May 17, 1901.)—If η denote the coefficient of viscosity of a non-associating liquid, the author has already found that $\eta T^3 = \text{const.} = E$; E is called the viscosity-parameter. Now Kamerlingh Onnes has deduced from the theory of corresponding states that for two liquids in corresponding states—

$$\eta_1 : \eta_2 = \frac{M_1^{\frac{1}{3}}\theta_1^{\frac{1}{2}}}{m_1^{\frac{2}{3}}} : \frac{M_2^{\frac{1}{3}}\theta_2^{\frac{1}{2}}}{m_2^{\frac{2}{3}}}$$

when M_1, M_2 are molecular weights, m_1, m_2 molecular volumes, and θ_1, θ_2 critical temperatures. Since—

$$\frac{E_1}{T_1^3} : \frac{E_2}{T_2^3} = \frac{E_1}{\theta_1^3} : \frac{E_2}{\theta_2^3},$$

it follows that the expression—

$$\frac{E}{\theta^3} \Big/ \frac{M^{\frac{1}{3}}\theta^{\frac{1}{2}}}{m^{\frac{2}{3}}} \quad \text{or} \quad \frac{M^{\frac{1}{3}}\theta^{\frac{7}{2}}}{Em^{\frac{2}{3}}}$$

has the same value for every liquid. Writing instead of m the molecular refraction

$$M_R \equiv \frac{M}{\rho} \cdot \frac{n^2 - 1}{n^2 + 2}$$

it follows that

$$\frac{M^{\frac{1}{3}}\theta^{\frac{7}{2}}}{E(M_R)^{\frac{2}{3}}} = \text{const.}$$

It is found that this is actually the case, the average value of the "constant" being 39,500. The author points out that the formula may be used to calculate approximate values for the critical temperature. F. G. D.

1615. *Internal Friction in Chrome Alum Solution.* **E. Ferrero.** (N. Cimento, 1. pp. 285–287, April, 1901.)—The internal friction in solutions of chrome alum begins to fall off slightly at 55°, at which temperature the colour begins to change from violet to green (a basic salt and free acid), and continues to fall until 80°, at which temperature it becomes practically constant. The difference in friction between the violet and the green solution diminishes as the solutions are weaker. A. D.

1616. *Internal Friction of Argon.* **H. Schultze.** (Ann. d. Physik, 5. 1. pp. 140–165, May 4, 1901.)—Details are given of experimental research and results for argon containing $\frac{1}{2}$ per cent. nitrogen. At 0° C.,

$$\eta_0 = 2104 \cdot 10^{-7}\ ;\ C = 169 \cdot 9\ ;$$

then at absolute temperature $\tau (= t^\circ\ C. + 1/\alpha$ where α is the coefficient of expansion),

$$\eta_\tau = \eta_0 \frac{1 + \alpha C}{1 + C/\tau} \sqrt{1 + \alpha t}.$$

This formula is based upon $\eta = 0 \cdot 30967 \rho \Omega L$ where Ω is in the arithmetical mean molecular velocity, L the mean free path, and ρ the density (O. E. Meyer, Kin. Theor. d. Gase. 2. Aufl., p. 189, 1899); $\Omega \propto \sqrt{1 + \alpha t}$; and $L_\tau = L_0(1 + \alpha C) \div (1 + C/\tau)$ where L_0 is the mean free path at 0° C. and C a constant depending on the cohesion (Sutherland, Phil. Maga., 1893); it gives better approximations than Rayleigh's formula. A. D.

1617. *Flow of Air past Obstacles.* **Marey.** (Comptes Rendus, 132. pp. 1291–1296, June 3, 1901.)—For studying the changes in the direction and velocity at different points of a column of air which is made to flow past an obstacle of given size and shape, the author employs thin columns of smoke which are injected into the air column. The flow takes place in a box of square section (the side of the square being 50 cm.), one of whose sides consists of a sheet of glass, so that the appearance of the smoke-lines may be photographed. The air and smoke are passed through suitable filters, so that when no obstacle is interposed the smoke-lines are straight and parallel to each other; 58 smoke-lines are employed by the author. The direction of the smoke-lines gives that of the air-current at any point. In order to study changes of *velocity*, the author adopts the ingenious expedient of throwing the series of small tubes through which the smoke is injected into lateral vibration by means of an electric trembler of known frequency. The effect is to produce sinuosities in the smoke-lines. These sinuosities are equi-distant, so long as the velocity along a given line is constant. If the velocity varies, its variation is deducible from the changes in the intervals between consecutive sinuosities. Samples of photographic records obtained by the author illustrate the paper. A. H.

1618. *Distribution of Molecular Energy.* **J. H. Jeans.** (Roy. Soc., Phil. Trans. 196. pp. 397–430, May 22, 1901.)—The author considers the difficulty to which the Maxwell-Boltzmann theory of gases leads in relation to the specific heats of substances. If the mean kinetic energy is the same for each degree of freedom, results follow which are irreconcilable with experiment. But the author remarks that Boltzmann's law of distribution of energy is proved to be the necessary law only if certain conditions postulated by Boltzmann are fulfilled. It fails altogether if there be dissipation, even though the conditions in other respects are fulfilled. There is dissipation if we admit any interaction, however small, between molecules and the surrounding ether. That such interaction exists is proved by the phenomena of radiation.

In the present paper the author confines himself to two forms of molecule, of which the first is the smooth loaded sphere referred to in Boltzmann's Vorlesungen, part ii. p. 129. This had been (but for an oversight) effectively treated by Burnside. The author assumes here the usual condition postulated by Boltzmann, viz., the independence of the velocities of the

spheres. If there be no dissipation we have all Boltzmann's conditions, and obtain, as others have obtained, Boltzmann's result, the equal partition of energy among the degrees of freedom. The author also shows the rate of approach to this final state, namely, if H be the energy of rotation (2 degrees of freedom), K that of translation (3 degrees), then as the result of collisions—

$$\frac{dH}{dt} = -\beta\rho\sqrt{K}(H - \tfrac{2}{3}K),$$

where ρ is the density, and β is a constant independent of the law of distribution. If the rotation be retarded by friction with ether, we have dissipation. Let w be the angular velocity, ϵw the rate of its retardation. Then the conditions for an approximately steady state are found to be that ϵ and β should be small, and $\epsilon\beta\sqrt{K}$ very great. Next we may suppose a molecule having many degrees of internal freedom. If we postulate with Boltzmann the independence of the velocities, then in the absence of dissipation we have all Boltzmann's conditions and his result. Also equations are obtained analogous to those above given. If there be dissipation, the co-ordinates may be divided into classes, according as the corresponding velocities are or are not retarded by friction. It is then found that the degrees of freedom require to be weighted as well as counted.

In Part II. the author comes to a more general type of molecule—namely, a molecule is a dynamical system, having $k + n$ degrees of freedom of internal motion, there being k co-ordinates $r_1 \ldots r_k$ which occur in the potential, and n, namely $p_1 \ldots p_n$, which do not. The corresponding velocities are $s_1 \ldots s_k$ and $q_1 \ldots q_n$. They are normal co-ordinates, so that the kinetic and potential energies are the sums of squares. Also the oscillations of the r's are assumed to be so small as to be isochronous. It is assumed that as regards the translations, Boltzmann's conditions prevail, the permanent state being denoted by $\phi(u, v, w) = \epsilon^{-h(mc^2 + 2\psi)}$, where ψ is a potential.

A distinction is drawn between encounters and collisions. So long, however, as there is no dissipation, the author's treatment does not differ in essentials from those of other writers on the subject, and he obtains, therefore, the usual result, that the Maxwell-Boltzmann distribution, or equal partition of energy, is in the steady state permanent, necessarily dependent as it is on the acceptance of Boltzmann's postulates.

But the author again introduces a dissipation function, expressing interaction of matter and ether, or radiation, and again it is found that the equal partition disappears. The degrees of freedom must be weighted as well as counted. A special solution is found for low temperatures, *i.e.*, below that of incandescence, on the hypothesis that by some external agency energy lost by radiation is restored to the body.

In Part III. are considered certain physical consequences of the theory. First, it is shown how if the main transfer of energy take place through collisions, the radiation may be a function of the temperature. A generalised theory of temperature is then given according to which a gas has a *principal temperature* T, corresponding to the mean kinetic energy of translation of its molecules, and subsidiary temperatures τ_1, τ_2, &c., corresponding to the mean energy of the several modes of vibration. At infinite temperatures these become equal to T; at temperatures below that of incandescence they are small compared with T. But the subsidiary temperatures may be influenced by chemical action. Also by the passage of light, certain modes of vibration

may be much increased in energy, giving rise to a bright band in the spectrum. It is found that the second law of thermodynamics will not generally hold for a gas emitting radiation. S. H. B.

1619. *The Boomerang.* **G. T. Walker.** (Phys. Zeitschr. 2. pp. 457–461, May 4, 1901.)—Among the many often accidental varieties of boomerangs, the author distinguishes two types. In the one the two arms of the boomerang meet under an angle which is not much larger than a right-angle, and are twisted in the sense of a right-handed screw. The other type, more obtuse and generally shorter, corresponds to a left-handed screw. With the former, most peculiarly complex curves can be described ; the latter rises in a fairly straight line and returns nearly on the same path. To increase the inertia of the missile, the author wound copper-wire round the middle and both ends. (Translation in *Nature*, pp. 338–340, Aug. 1, 1901.) H. B.

1620. *Equilibrium Forms of Powdered Masses.* **F. Auerbach.** (Ann. d. Physik, 5. 1. pp. 170–219, May 4, 1901.)—The experiments were made with grains of sand, limestone, glass, lead, various seeds, &c., not less than 0·01 cm. in diameter, heaped up by four methods : (1) The powder was poured on the base ; (2) the base was held a little above a table which, along with the base, was covered with the powder, and a small instrument was then gently applied to the edges of the base ; (3) the base rested on the table which was all covered with material, and was then lifted ; or (4) the table was lowered. Bases of various forms were applied. When the powder is heaped up in the corner, formed by two walls of unlimited length at right angles to one another, the normal slope is plane, curved over, however, towards either plane. Convexity of the horizontal section diminishes the slope, concavity increases it. The figures over polygons as bases are pyramids with rounded-off edges and points ; this rounding-off is least for triangles and is proportional to the size of the grain. Over a circular base, an hyperboloid of revolution is formed ; the hollow, formed by the inner ring wall when a circular hole is made in the base, is also an hyperboloid of revolution. The normal slope varies between 21° and 36° ; it is the greater, the smaller, lighter, rougher, and less round the grains, and may assume any value between 0° (apex of the rounded-off cones) and 90° (over small holes). The author discusses the theory and shows that it is confirmed by his experiments. H. B.

1621. *Gravitational and Magnetic Fields.* **R. Eötvös.** (International Physical Congress at Paris, Report, 3. pp. 371–393, 1900.)—By a torsion balance method the author determines the derivatives of the components of gravity in the neighbourhood of a point, thus finding the curvature of the equi-gravitational surface at that point, the curvature of the line of force, the tangent to the equi-gravitational curve, and the gradient of variation of the gravitational force. These data give indications as to the probable distribution of masses causing these variations. The method is exceedingly sensitive, and gives indications of underground rocks and their distribution : it is far more sensitive than any pendulum method. Bessel's conclusion that attraction was independent of the nature of the attracting masses to within $\frac{1}{10000}$ has been pushed very much farther. The sun's attraction is not modified one hundred-millionth part by the interposition of 1 km. thickness of the earth's crust. Similar methods have been applied to the exploration of magnetic fields. A. D.

1622. *Thermal Deformation of a Balance.* **W. Felgentraeger.** (Ann. d. Physik, 5. 1. pp. 234–235, May 4, 1901.)—In reply to the contention of Middel [see Abstract No. 1395 (1900)] that the balance used for determining the density of the earth is deformed owing to the unequal expansion of rolled and cast brass, the author maintains that a much more likely explanation of the variation of sensitiveness may be based upon the difference in expansion of the brass beam and the steel knife-edges. He shows by calculation that the difference indicated by theory is in practical agreement with the observed variation. E. E. F.

1623. *Relations between Earthquakes and Detonations.* **J. Knett.** (Akad. Wiss. Wien, Sitz. Ber. 109. I. pp. 700–734, 1900. Report of the Earthquake Commission of the Academy.)—Although the precursory waves which cause the tremor, the first indication of a distant earthquake, are as a rule also the carriers of the noises which accompany the earthquake, the detonations are sometimes out of all proportion to the mechanical concussion and must be independent acoustical phenomena. The detonations appear to be propagated, not by the preliminary tremor, but by the main waves, and their intensity accords generally with the surface concussion. But we have very little experimental material concerning the observation of submarine explosions at a distance. Detonations might be caused by an outburst of a large volume of confined gas and a breakdown of natural or artificial cavities. H. B.

1624. *Detonations in the Duppau Mountains, Aug.* 14, 1899. **J. Knett.** (Akad. Wiss. Wien, Sitz. Ber. 109. I. pp. 735–767, 1900. Report of the Earthquake Commission of the Academy.)—The locality is east of Karlsbad, the ground basalt and basaltic tuffa, overlying granite. Two detonations were heard, the second one feeble, and two tremors were felt, the second one very weak. The data are very scanty. The phenomena were chiefly noticed in a circle, about 13 km. in diameter, and to the north of it, not to the south. The disturbance was not felt at the epicentre, and originated probably at a depth of 9 km. The impulse seems to have been directed N.N.E. and struck the surface a little to the north of the epicentre. Allusion is made to refraction of the waves in strata of different densities. The cause of the phenomenon was possibly an outbreak of carbon dioxide gas. H. B.

1625. *Volatile Gases in Atmospheric Air.* **G. D. Liveing** and **J. Dewar.** (Roy. Soc., Proc. 67. pp. 467–474, Feb. 5, 1901; also Cambridge Phil. Soc., Proc. 11. pp. 107–8, April 22, 1901.)—By a special process [Abstract No. 592 (1899)], tubes were filled with the more volatile gases of the atmosphere which were not condensed at the temperature of liquid hydrogen, and these tubes containing the residue of uncondensed atmospheric gases were examined spectroscopically. In the spark spectra obtained strong rays in the red, orange, and yellow are attributed to hydrogen, helium, and neon; but other lines appear in the photographic record of the spectrum which seem to be due to unknown substances. As the mixture of gases probably included some of all such gases as pervade interplanetary and interstellar space, search was made in their spectra for the prominent nebular, coronal, and aurora rays. Although the residual gases of the atmosphere uncondensed at the temperature of liquid hydrogen do not show the nebular lines, it was found that another tube gave a ray very close indeed to the green nebular ray and appearances seem to indicate that the substance which is luminous in

nebulæ may be really present in the earth's atmosphere. Faint rays were also observed whose positions correspond approximately to the stronger rays in N. Lockyer's list of coronal lines. With regard to these questions and also to the possible occurrence of auroral rays in the spectra of the gases, the authors intend to carry out farther investigations. Photographs of the ultra-violet rays were obtained by a quartz-calcite train of prisms, but the rays had to pass through the glass of the containing tube. A list of the approximate wave-lengths of the rays, visible and ultra-violet, observed about the negative pole, is given. J. J. S.

1626. *Enhanced Lines in the Spectrum of the Chromosphere.* **J. N. Lockyer and F. E. Baxandall.** (Roy. Soc., Proc. 68. pp. 178–188, May 23, 1901.)—This paper is essentially a reply to the report of the results obtained by the Yerkes Observatory party during the eclipse of May 28, 1900. In this report Frost concludes from a discussion of the lines photographed and their origins that the "enhanced lines" of the various elements concerned do not appear to occur in any systematic manner among the bright chromospheric lines. The authors of the present paper show conclusively that this reasoning is doubtful, obtained probably by the selection of the origins from coincidences in wave-length with the Fraunhofer lines in Rowland's table of solar spectrum standard lines. If the lines are discussed according to their relative intensity, it is seen from the tables provided in the paper that 80 per cent. of the enhanced lines of titanium alone agree with eclipse lines within 0·3 tenth metre. Further tables support the same conclusion by giving a summary of Hasselberg's *arc* lines, from which it is seen that these are not prominently represented. The question is also discussed in relation to the lines of iron. C. P. B.

1627. *Wedge Photometer applied to Measurement of Photographic Magnitudes of Stars.* **B. Baillaud.** (Comptes Rendus, 132. pp. 1091–1094, May 6, 1901.)—By arranging for suitable illumination of the background, the wedge photometer can be used to extinguish the dark images of stars on negatives, just as it is used to extinguish the bright images of stars in the focal plane of an ordinary telescope. The writer has constructed an apparatus for the purpose, a description of which will, he says, be given elsewhere. The registration is mechanical. The present paper explains how the scale was graduated, and tested by observations of known stars. The question is complicated by the fact that for a constant dark image on a variable bright background the extinction readings are not proportional to the logarithm of the brightness of the star, as is the case for a bright star on a dark ground. There is further difficulty owing to the size of the images of brighter stars. Results of observations so far have been satisfactory. It was noted that multiplying the time of exposure by 3·1 altered the images of all stars by one magnitude. A. E.

REFERENCES.

1628. *Muscular Energy.* **A. Chauveau.** (Comptes Rendus, 132. pp. 938–944, April 22, 1901.)—Further particulars of the work referred to in Abstract No. 754 (1901). H. B.

1629. *Atmospheric Radiation.* **W. Hallock.** (Amer. Journ. Sci. 11. pp. 230–234, March, 1901.)—Comments on F. W. Very's paper [Abstract No. 344 (1901)]. H. B.

LIGHT.

1630. *Propagation of Cusped Waves, and their Relation to the Primary and Secondary Focal Lines.* **R. W. Wood.** (Phil. Mag. 1. pp. 589–593, May, 1901. Paper read before the Phys. Soc. of London.)—This article is a sequel to a former paper (Phil. Mag. July, 1900, p. 148), without reference to which it will be found difficult to follow. The case of reflection of a plane wave by a hemispherical mirror is here further dealt with. The reflected wave, as previously shown, is cusped, the locus of the cusps being the caustic. The wave has something of the form of a volcanic cone with a crater, and the author shows that the outer wall of the "volcanic cone," before it crosses the axis of the mirror, represents the portion of the wave-front between the primary and secondary focal lines. While the "crater" is concave along every meridian, the outer wall is saddle-shaped, being convex along one meridian, and concave along the meridian at right angles to it. On inspecting the diagram usually given to illustrate the formation of focal lines, it will be seen that the wave-front between the two focal lines has this required saddle-shape. The author has made a model of the wave-front by softening a wide, thin tube, sucking in the closed end, and widening the open end. Another simple piece of apparatus for teaching purposes can be made by silvering the outside of a hemispherical glass dish, placing it on a stand, and arranging a two-candle electric lamp to move along the axis, the reflected rays being received on a piece of ground glass. An error sometimes made is pointed out, namely, the assumption—say in the case of a spherical wave refracted at a plane surface—that the wave-fronts are hyperboloids in the second medium, because the caustic is the evolute of a hyperboloid. The correct statement is that they are the parallels to a hyperboloid. A. E.

1631. *Microphotometer for measuring Absorption of Light.* **J. Koenigsberger.** (Zeitschr. Instrumentenk. 21. pp. 129–133, May, 1901.)—The instrument is only adapted for the visible spectrum. The following advantages are aimed at in the construction: (1) High degree of accuracy in a single measure; (2) possibility of determining absorption of very small portions, ($\frac{1}{2}$ to 1 sq. mm.) of the material examined, (solid substances, except glass, not being truly homogeneous in large masses); (3) adaptability for light of any degree of homogeneity. A diaphragm with two equal rectangular openings of 3 × 5 mm., 1 mm. apart, is placed under a rhomb of calcspar 24 mm. in height, cut with its faces at 55° to the optic axis, and both are placed under the microscope. Owing to double refraction, four images of the two holes are formed by the objective, the two central images partly overlapping. Only these two are seen by the observer, as a diaphragm at the focus of the eye-glass cuts off all the rest of the field. The light is so arranged that, when nothing is in the way, both holes are equally illuminated, and the two images therefore receive equal quantities of light polarised in different directions. If now an absorbing medium be placed below one hole, then the amount of light polarised in one direction exceeds that polarised in the other. This is betrayed by the appearance of bands produced by a Savart's polariscope (see below). The light entering the second hole is then weakened, by means permitting of measurement, until the disappearance of the bands shows that the two quantities of polarised light are again equal. This is done either by

iding a graduated wedge, or rotating a Nicol with divided circle attached, elow the hole. The Savart's plate, consisting of two crossed plates of calc-par, 5 mm. thick, cut at 45°, is placed above the microscope objective, either n the objective itself, or in a separate revolving ring. A fixed Nicol is inserted n the tube between the ocular and the plate. The microscope objective is an chromatic lens of 6 to 9 cm. focus. A little telescope adjusted for infinity, vith objective of 5 cm. focus, serves as ocular. The sensitiveness of the pparatus is due to the easy visibility of the bands. Heightened effect, owing o contrast, is produced by covering half of each hole with a piece of cover lass. The author states that results of numerous trials show the performance f the apparatus to be at least equal to that of the best photometers hitherto n use. The discrepancies for blue and violet were much larger than for ther colours—a result not accounted for by their weaker intensity, since neasures with strong illumination were no better than with weak. The uthor thinks the difference must have a physiological origin, and wonders whether other observers have had a similar experience. A diagram illustrating he principle of the apparatus was given in a previous number (Ibid. 21. p. 59, 1901); a sketch of a later form accompanies this paper. A. E.

1632. *Determination of Wedge-Constant of Stellar Photometer.* **J. A. Parkhurst.** (Astrophys. Journ. 13. pp. 249–259, May, 1901.)—E. C. Pickering, of Harvard College Observatory, has organised a co-operative system of determinations of faint stellar magnitudes, and the present paper deals with the investigation of the constants, &c., of the instrument sent to the Yerkes Observatory for the furtherance of this work. Sectional drawings and photographs of the instrument are given to show its construction. The light from an artificial source is passed through a small aperture and then reflected from *both* surfaces of a plane-parallel glass plate into the ocular, forming *two* images of the artificial comparison source. The image of the real star is then brought between these, and the light from the artificial source is varied in intensity by a movable interposed photographic wedge until equality is obtained with the real star.

Particulars are given of the calibration of the wedge by the "revolving wheel" method, in which the light can be reduced by known amounts. Tables are given showing relation of determined magnitudes to those of other institutions. C. P. B.

1633. *Relative Brightness of Sun and Sky.* **Q. Majorana.** (Phil. Mag. 1. pp. 555–562, May, 1901. Translated from Accad. Lincei, Atti, 9. Aug. 5, 1900.)—The apparatus used is small and easily portable. Two tubes, T_1 and T_2, intended to be turned towards sun and sky respectively, revolve independently at right angles about a third tube T_3, which serves as ocular tube. Rays passing down T_1 and T_2 are reflected up T_3 by mirrors at 45°, the mirror nearer the eye having a hole in it to let the rays from T_1 pass through. The whole is mounted on a ball-and-socket joint. T_1, the solar tube, has at its end a diaphragm with a small hole, behind which is a short-focus lens. The sky tube, T_2, is completely open at the end, but has an iris diaphragm, D, at its centre. In both tubes the light passes through two ground-glass screens. The eye by means of the ocular tube sees an azure field illuminated by the sky, and in its centre a white or reddish spot due to the sun. The aperture of D is adjusted so as to give equal illumination of the two areas. The instrument was calibrated by artificial light. Observations were made at Rome and Catania. The luminosity of the sky varies from point to point. Thus on an

August day at 11 a.m. the following values were found for r, the ratio of the sun's brightness to that of the sky:—close to sun 357,000, 90° from sun 950,000, horizon 98,000, white cloud 18,000. "The variations are evidently due for the most part to the presence of aqueous vapour." The luminosity also varies during the day. Observations made during seven hours on one day in August gave, at 90° from the sun, values of r varying from 175,000 at 6 a.m., up to 950,000 at noon, and down again to 225,000 at 6 p.m. But the figures change considerably with altitude. On the summit of Etna (2,942 m.) r was found to have sensibly the same value for all regions except those close to the horizon, and to be about five times greater than at Catania. On a very clear day r was 2,570,000 at 5.50 a.m., and 3,760,000 at 11 a.m. Almost simultaneously Sella on Monte Rosa found values of r about 5,000,000. Hygrometric observations were taken, but no relation was found between humidity and relative brightness. A. E.

1634. *Measurement of the Action of Light on Photographic Plates.* **F. F. Martens** and **F. J. Micheli.** (Archives des Sciences, 11. pp. 472–487, May, 1901.)—The authors describe an instrument designed by them for measuring the opacity of photographic plates. The instrument is fixed on a box having a hole in the cover, over which is placed the plate; from the side of the box projects horizontally a tube closed with an opal glass, before which is placed a lamp. The rays from this follow two paths, either going into the box and being reflected vertically upwards by a prism through the plate, or passing along a tube above the plate and being reflected upwards by a second prism. The two rays, one having traversed the plate, are collected by a lens, then pass through in succession an objective, a double-refracting Wollaston prism, a double prism, a Nicol, and an eyepiece. The prisms are arranged so that half the field of the eyepiece is illuminated by one set of rays and the other half by the other set, the two sets of rays being polarised perpendicularly. The two fields are made equally bright by rotating the Nicol, which is provided with a pointer and scale.

If a and a' are the angles of rotation of the Nicol for two plates, transmitting light of intensities J and J', $J/J' = \tan^2 a'/\tan^2 a$. If Jf, Jd, and Je refer to plates respectively (1) fixed without exposure, (2) developed and fixed without exposure, and (3) exposed, developed, and fixed, the authors define as absolute blackening in per cent., $100\,\frac{Jf-Je}{Jf}$, as absolute density, $\log\frac{Jf}{Je}$, as relative blackening, $100\,\frac{Jd-Je}{Jd}$, and relative density $2-\log\frac{Jd}{Je}$; multiplying the latter quantity by 0·0115, gives the quantity of silver deposited per 100 sq. cm. due to the action of the light. The authors give two curves between the relative blackening and the illumination in candle-metre seconds, one curve for constant time of exposure with constant light at varying distances, the other for constant candle-metres and varying time of exposure. The slight difference between the two curves is attributed to inequalities in the gelatine or development. G. H. B.

1635. *Differential Double Refraction.* **E. J. Rendtorff.** (Phil. Mag. 1 pp. 539–548, May, 1901.)—Crystal plates were compared to test their suitability for achromatic combinations, such as quarter-wave plates. The method was similar to that used by D. B. Brace. [See Abstract No. 53 (1900).] Each crystal plate was in the form of a double wedge, to permit of

the thickness being altered. This plate was placed between crossed Nicols so that the principal axis was at 45° to the plane of polarisation, and was examined with a spectroscope. Under such circumstances the spectrum is seen crossed by a series of black interference bands, which move along as the thickness of the crystal is changed. The order N of the plate is found from the formula $N = mn/(1 - n)$, m being the number of bands which have passed, say, the D line, and n the ratio of the initial to the final number of bands between two given wave-lengths. For comparison of a pair of crystals the apparatus was arranged so that the two interference spectra were seen in contiguity in the telescope. The thicknesses were then varied until the best coincidence of the bands was obtained in the part of the spectrum which it was desired to achromatise, when the orders were found by help of the above formula. For higher orders plane plates were used in conjunction with the double wedges. The crystals examined were Iceland spar, quartz, selenite, and mica. Mica and selenite, as well as Iceland spar and quartz, give a good coincidence of bands throughout the spectrum ; with other combinations it was possible to achromatise for certain portions only. The best coincidences with sodium light were obtained with the following combinations : Mica order 40 + selenite order 35, mica 45 + quartz 40, quartz 222 + Iceland spar 212, selenite 210 + quartz 594. One of the diagrams shows the relative positions of the bands in the spectrum for selenite and quartz. The orders 67 selenite and 66 quartz give good coincidence in the most intense region of the spectrum.

D. B. Brace, in a note, remarks that "in this method of determining the order of crystal plates no error is ordinarily possible, it being merely a matter of counting." Previous methods have entailed inaccuracies, and tables of indices must therefore be erroneous to some extent. Corrected data are being tabulated. He discusses Dupet's determinations of the optical constants of selenite. A. E.

1636. *Cyanin Prisms and Anomalous Dispersion.* **R. W. Wood.** (Phil. Mag. 1. pp. 624–627, June, 1901. Paper read before the Physical Society of London.)—The cyanin used by the author in former experiments was so opaque that it did not allow of prisms being used of greater angle than 20 or 30 minutes. [See Abstract No. 791 (1901).] With a new sample of the dye which is much more transparent, prisms have been prepared of one degree refracting angle, and these transmit the green light better than the former ones. The spectrum of an incandescent lamp filament viewed through the prism is anomalous, the order of the colours being green, blue, violet, red, and orange. Combining one of these prisms with a diffraction grating enables the curves of dispersions to be beautifully demonstrated. J. B. H.

1637. *Mica Echelon Grating.* **R. W. Wood.** (Phil. Mag. 1. pp. 627–629, June, 1901. Paper read before Physical Society of London.)—The author has succeeded in making an echelon grating with only laboratory appliances, the plates being composed of thin sheets of selected mica. The sheets were examined with the interferometer, and the most suitable cut up into rectangular pieces. The retardation of each was about 50 wave-lengths for sodium light. The grating space was 0·5 mm., nine plates being used, giving a resolving power of about 500. The apparatus is of special use for class demonstration in being intermediate in power between the ordinary grating and the full-strength echelon. C. P. B.

1638. *Spark Spectra without Air Lines.* **A. Miethe.** (Phys. Zeitschr. 2. pp. 267–268, Feb. 2, 1901.)—An apparatus, with diagram, is described which is designed to give spark spectra in air which are free from air lines, it having been found that with suitable self-induction a spark at break has a spectrum in which the lines due to air are absent. The spark is made between a fixed and a movable electrode in the circuit of a battery and self-induction coil. The movable electrode is attached to a spring set in vibration by means of the hammer interrupter of a coil with iron core worked by another battery. The spectrum of radium was examined by means of the apparatus, the radium being obtained by repeated fractional crystallisation of active barium bromide by Giesel's method. The radium spectrum contained, besides lines due to barium and faint platinum lines, some calcium lines in the blue violet. A large number of radium lines were found between the wave-lengths 500–700. A Curie preparation of radium gave a spectrum which coincided with the first, as regards the position but not the intensity of the lines. G. E. A.

1639. *Banded Spectra of Alumina and Nitrogen.* **G. Berndt.** (Ann. d. Physik, 4. 4. pp. 788–795, April, 1901.)—Experiments were made to determine whether the banded spectrum of aluminium was due to metallic aluminium or its oxide. The conclusion of the author is that for the production of the banded spectrum the presence of oxygen is always necessary, and that the spectrum is in reality that of alumina. The spectrum of nitrogen is also considered, and as an appendix to the paper an elaborate list of the wave-lengths of the lines in the band spectrum of nitrogen is given. J. J. S.

1640. *Wave-lengths of some Iron Rays.* **C. Fabry** and **A. Perot.** (Comptes Rendus, 132. pp. 1264–1266, May 28, 1901.) — Wave-lengths measured [see Abstract No. 69 (1901)]; values found, in arc-light, are as follows: 649·4992, 623·0733, 606·5489, 576·3023, 561·5657, 558·6775, 550·6783, 543·4525, 530·2321, 523·2954, 508·3345, 500·1887, 485·9763, and 473·6785. A. D.

1641. *Constitution of a Luminous Gas.* **J. J. Thomson.** (Archives Néerlandaises, 5. pp. 642–643, 1900.)—The refractive index μ of a gas for light whose vibration-frequency is p was shown by Lorentz to be given by the equation :—

$$\frac{\mu^2-1}{\mu^2+2}=\frac{4\pi}{3}\Sigma\frac{Ne^2V_0^2}{m(n^2-p^2)} \quad \ldots\ldots\ldots\ldots(1)$$

where e is the charge and m the mass of an ion; n the frequency of a free vibration, N the number of ions vibrating with this frequency, V_0 the velocity of light in a vacuum, the summation being taken for all the modes of vibration of the molecule, *i.e.*, for all the lines in the spectrum of the gas. For very long waves p is approximately zero, and $\tau\mu^2 = K$, the specific inductive capacity of the gas. If λ is the wave-length corresponding to the frequency n, then $v/n = \lambda/2\pi$ and equation (1) becomes—

$$K-1=\Sigma\frac{Ne^2}{4\pi m}\lambda^2 \quad \ldots\ldots\ldots\ldots(2)$$

In the denominator of the left-hand side of equation (2), K + 2 has been put equal to 3, as K for all gases is approximately unity.

From the spectrum of the gas the various values of λ can be determined, and if it be assumed that all the molecules can give out the vibration whose wave-length is λ, Ne can be found. If the vibrating ion is negatively

charged, $e/m = 10^7$. Applying this formula to some gas, *e.g.*, helium, each line in the spectrum will contribute to the right-hand side of equation (2), so that if only one line is taken into account the estimated value of $K - 1$ ought to be too small. Supposing all the molecules of helium to be giving out the yellow line $\lambda = 5{\cdot}9 \times 10^{-5}$, N being the number of molecules in 1 c.c. of any gas at atmospheric pressure and temperature, and e having the smallest possible value, viz., the charge on the H ion in the electrolysis of solutions (e being measured in electromagnetic units), since one unit liberates 1·23 c.c. of hydrogen, $Ne = 0{\cdot}4$. Putting in these values and taking account of the yellow line only, $K - 1$ from equation (2) would be $1{\cdot}1 \times 10^{-3}$; the actual value is $8{\cdot}5 \times 10^{-5}$. Thus the calculated value is thirteen times the real value and only one of the lines of helium has been taken into account. In the case of the gases tried, the value of $K - 1$ obtained from equation (2) is found to be enormously too large if it is assumed that every molecule of the gas can give out every line in the spectrum. This suggests that in a luminous gas the spectral lines are not given out by every molecule of the gas, but by only a comparatively small number of systems formed in some way out of the molecules, perhaps by aggregations of greater complexity than the molecules. The systems which give out one line may be different from those giving out the others. This would afford an explanation of the extraordinary variations which sometimes take place in the relative brightness of the lines given out by a gas when the circumstances are changed. The number of lines in the spectrum of a gas may not be necessarily connected with the number of degrees of freedom of the average molecule—a result which is of some importance in connection with the theory of the ratio of the specific heats.

J. J. S.

1642. *Direct Production of Röntgen Rays in Air.* **A. Nodon.** (Comptes Rendus, 132. pp. 770–772, March 25, 1901.)—Experiment shows that Röntgen rays may be produced directly in air, and outside the Crookes vacuum. They are produced under the simultaneous action of ultra-violet rays and of an electric field. If an electric field is set up between the plates of an air condenser and a pencil of ultra-violet rays is directed on to one of the plates, Röntgen rays are produced. These Röntgen rays are propagated along the same direction as the lines of electric force of the field. They are not emitted in other directions. They possess greater activity when the direction of the lines of force of the field is the same as that of the propagation of the ultra-violet radiation, that is when the illuminated plate of the condenser is the negative one. The activity of the emitted Röntgen rays is a function: (1) of the intensity of the electric field; (2) of the intensity of the ultra-violet radiation; (3) of the wave-length of the latter; (4) of the nature of the substances at whose surface they originate. The general properties of the Röntgen rays produced directly in air are indentical with those of the X-rays produced by means of the Crookes tubes. They discharge electrified bodies after their passage across aluminium, and in various ways their action corresponds to that of Röntgen rays otherwise produced. J. J. S.

1643. *Röntgenised Gases.* **E. Villari.** (International Physical Congress at Paris, Report, 3. pp. 152–163, 1900.)—Röntgenised air and gases are deprived of their power of dissipating electric charges when they are sent through an ozonator in action, or through the same ozonator for some time after the current actuating it has been broken, this time in the latter case being longer the longer the time for which the actuating current has been kept up. The

ozonator becomes charged with two kinds of electricity; and it may be partially discharged and its neutralising power diminished by reversing the actuating current. The charges in the ozonator, in neutralising the Röntgenised air, neutralise each other or disappear in transforming Röntgenised into ordinary air. Gases become able to discharge electrified bodies if long inductor sparks be sent through them, the more so the longer the sparks within certain limits; and they retain this property for some time and even after passing through glass or metal tubes several metres long and 2 cm. in diameter. An ozonator will undo this effect produced by sparks and will go on doing so for some time after the current actuating it has ceased. The discharging power of products of combustion is only partly taken away by cooling, but is entirely so by an ozonator in action; but the effect of the ozonator rapidly falls off when its actuating current ceases. A tube charged positively or negatively will deprive Röntgenised air of its discharging power; but the tube very slowly loses its charge, and along with this its power of neutralising Röntgenised air. Röntgenised air behaves as an actual conductor of electricity; but there appears to be no increase in its thermal conductivity. Röntgenised air loses its discharging power by friction; and on being passed through bent tubes it does so much more rapidly than when passed through the same tubes straight; the material of the tube seems to make no difference. Electric charges can be developed by the impact of Röntgenised air on large surfaces, metallic or non-metallic. The sign of the charges does not depend on the nature of the metal employed but on the condition of friction; if the Röntgenised air pass quickly and lightly over metallic surfaces these are charged negatively, if slowly and under more pressure then positively. The air ought perhaps to acquire an opposite charge: but it seems that the contrary is the case, the opposite charge being possibly absorbed in effecting the transformation from Röntgenised into ordinary air. A. D.

1644. *Negative Electrification of Secondary Rays.* **P. Curie** and **G. Sagnac.** (Soc. Franç. Phys., Bull. 165. pp. 4–5, 1901.)—While Röntgen rays do not appear to be electrically charged, the secondary rays excited by the impact of the Röntgen rays on zinc, tin, and platinum carry a negative flux of the order of 10^{-10} ampere; those from aluminium do not do so, and are otherwise much like the Röntgen rays from which they originate; while those from Zn, Sn, and Pt are much more easily absorbed than the corresponding Röntgen rays. Correspondingly, the rays from Al do not, while those from Pb and Pt do, contain radiations deviable by the magnet in addition to those not deviable (Dorn). The metal from which secondary rays have carried a negative charge acquires a positive charge. That the charged component of the secondary radiations should be deviable by the magnet is in accord with the analogy between secondary rays and radio-active rays pointed out by Mme. Curie, and with the analogy between Röntgen rays and ultra-violet light which can cause kathode discharges. A. D.

1645. *De-ionisation of Air.* **E. Villari.** (Phil. Mag. 1. pp. 535–538, May, 1901. Paper read before the Phys. Soc. of London.)—Air ionised by Röntgen rays is here passed into metallic filters of various kinds, and the charge given to the filter is measured as well as the charge remaining on the air. The filters used consisted of tubes carefully insulated and filled with metal in the form of rolled sheet, rolled gauze, filings, or wire. In some experiments the sign of the charge on the filter was positive while in others it was negative.

The difference was finally traced to the force of impact of the air particles on the metal in the filters, a reversal of sign taking place in some filters according as the air was blown more or less gently through the cylinder.

The air after passing through the filters had not lost all its discharging properties and had a small charge of the same sign as that on the filters.

J. B. H.

1646. *Conductivity of Gases under Becquerel Rays.* **R. J. Strutt.** (Roy. Soc., Phil. Trans. 196. pp. 507–527, June 8, 1901. Abstract in Roy. Soc., Proc. 68. pp. 126–128, May 4, 1901.)—The author describes experiments on the conductivities produced in different rarefied gases by radiations from various radio-active substances. The method adopted was to measure the rate of leakage from a charged plate through the gas exposed to radiation to a parallel insulated plate connected to the insulated quadrants of an electrometer. The special arrangements are described. The radio-active substances used gave respectively radium radiation, polonium radiation, and uranium radiation. Radium gives two distinct kinds of rays, one easily absorbed by gases and solids and not deflected by magnetic force, the other more penetrating and deflectable by the magnet. Both kinds were investigated. Uranium also gives these two types, but as only a very small fraction of the total conductivity is due in this case to the penetrating type, only the absorbable rays have been investigated. The results are given in a table, which may be usefully reproduced here, especially as it includes, for comparison, J. J. Thomson's and Perrin's results for conductivities under Röntgen rays, and McClelland's results for kathode rays. The two columns for polonium refer to two different preparations, the second giving more powerful radiation than the first. In these experiments air is taken as the standard.

Gas.	Relative density.	Relative conductivity.							
		Röntgen rays.		Kathode rays.	Radium rays.		Polonium rays.		Uranium rays.
		J. J. Thomson.	Perrin.		Penetrating type.	Absorbable type.	I.	II.	
Hydrogen	0·0693	0·33	0·026	0·069	0·157	0·218	0·226	0·219	0·213
Air.....	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00
Oxygen	1·11	—	—	1·106	1·21	—	1·16	—	—
Hydrochloric acid	1·27	8·9	8	—	1·46?	—	—	—	—
Carbonic acid..	1·53	1·4	1·34	1·53	1·57	—	1·51	—	—
Cyanogen	1·86	1·05	—	—	1·86	—	1·94	—	—
Sulphur dioxide.....	2·19	6·4	6	—	2·32	1·92	2·04	2·03	2·08
Chloroform....	4·32	—	—	—	4·89	—	4·44	—	—
Methyl iodide	5·05	—	—		5·18	3·74	3·51	3·47	3·55
Carbon tetrachloride	5·31	—	—	—	5·83	—	5·34	—	—

In the case of the penetrating type of Becquerel rays, these results show that the relative conductivity of gases is mainly dependent upon their densities. McClelland's results show this same proportionality in the case of kathode rays. These penetrating Becquerel rays are now generally considered to consist of a stream of negatively charged ions travelling with enormous velocities, and the author now suggests that the absorbable rays may consist of a stream of positive ions. As the positive ions, though carrying the same

charge, have an enormously greater mass than the negative ions, this theory would explain the want of penetration of these rays, and also the fact that they are less easily deflected; but it would be worth while to see if they suffer deflection in a very powerful field. W. C. H.

1647. *Thermo-luminescence by Radium Rays.* **E. Wiedemann.** (Phys. Zeitschr. 2. p. 269, Feb. 2, 1901.)—This has been shown for uranium rays by Borgmann, and H. Becquerel has shown that thermo-luminescence of fluor-spar may be induced by radium. The present notice describes how the effect may be made visible for a lecture experiment. The radium preparation is placed in a hollow glass plate and covered with aluminium. The luminescent substance ($CaSO_4 + xMnSO_4$) is placed in a thin layer on an aluminium plate covered with mica, and the edges of the aluminium turned over. The radium is then allowed to act on this for an hour or two, after which the aluminium plate is transferred to a hot copper plate. A green disc appears at the spot above which the radium lay. G. E. A.

1648. *Induced Radio-activity Provoked by Radium Salts.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 132. pp. 548–551, March 4, 1901.)—A description of farther experiments on induced radio-activity, from which it appears that it is much more intense when the experiments are carried out in a closed vessel. Rays which are very easily absorbed are alone able to intervene, and they act on the air in immediate contact with the radiant matter. This action appears to be transmitted step by step through the air between the radiant matter and the body acted upon. (It can be transmitted through very narrow capillary tubes.) Rutherford's theory of emanation explains sufficiently well the facts observed, but other satisfactory explanations may be conceived, and it is considered premature to adopt any theory, as new facts are necessary to elucidate the question. J. J. S.

1649. *Induced Radio-activity and the Action of Radium on Gases.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 132. pp. 768–770, March 25, 1901.)—It was sought to determine the part played by the intervening gas in the communication through the air of the radio-activity of a radium salt to a body rendered active in its turn. The following is a summary of the new results obtained:—

The active matter contained in an open glass tube was placed with the body to be acted upon (a sheet of copper, for example) in a sealed tube filled with air at atmospheric pressure. The body gradually becomes radio-active, and in the end attains a limited activity, always the same for the same radio-active matter. When hydrogen replaces air the same limited "activation" is observed. When the pressure of the air in the tube is varied and made somewhat low (1 cm. of mercury) the limit of activation is still the same. Consequently the quantity and the nature of the gas present have no influence on the induced radio-activity.

The result is no longer the same when, instead of a partial vacuum, a very perfect vacuum is produced in the tube ($\frac{1}{1000}$ of a millimetre of mercury), and *when this vacuum is maintained throughout the experiment* by causing the mercury pump to work continuously during the experiment. Under these conditions the body does not become active, and if it was already in an active state its activity disappears. Thus radio-activity is no longer propagated when all pressure in the apparatus is suppressed.

If after the production of a very perfect vacuum the apparatus is cut off

from the pump, it is found that after an interval the sheet of copper becomes as strongly active as in air. This reappearance of radio-activity coincides with the appearance in the tube of occluded gases which raise the pressure to a slight extent. These occluded gases have been collected and their spectra examined. Carbon gases predominate, and hydrogen, nitrogen, and mercury vapour are also indicated.

The collected gases, in spite of their small mass, are strongly radio-active. They act across the glass of the tube and affect a photographic plate enveloped in black paper, and discharge very rapidly electrified bodies. Such is their activity that they also provoke fluorescence of the glass of the tube which becomes luminous in the dark. This activity of the gases steadily diminishes, but very slowly, so that gas collected and kept for ten days is still very strongly active.

The air of the laboratory in which the authors have worked for some years has become progressively more and more conducting, so that it is no longer possible to have a well-insulated apparatus, and only rough measurements can be taken with the electrometer. It is thought that this condition is not due to powders of radio-active substances which may be disseminated in the laboratory, but to the continuous formation of radio-active gases analogous to those mentioned.

The mechanism of the propagation of induced radio-activity is not yet elucidated. It may be considered that the ordinary gases contained in the air may become active from contact with radio-active matter, and then diffusing, communicate by contact their activity to other bodies; but many facts cannot be explained thus, limited activation being independent of the pressure and nature of the gas, and, moreover, the propagation of activity through capillary tubes being apparently much too rapid to be explained as due to simple diffusion of the gas. J. J. S.

1650. *Fluorescence in Diamonds.* **A. L. Foley.** (Science, 13. pp. 732–734, May 10, 1901.)—The author found that when photographic dry plates, which had been cut with a diamond on the side opposite the film, were developed, the film turned dark along the edge of the plate to the breadth of a few millimetres. The film always developed first on the side next the glass. The author traces this effect to a momentary fluorescence along the line traced by the diamond, the radiation penetrating the plate and fogging the film to a breadth

$$b = 2t.\tan i,$$

where t denotes the thickness of the glass and i is the critical angle. In every experiment, using plates of different thicknesses, it was found that b varied as t. The fluorescence depends upon the kind of glass in the plate, and also upon the particular diamond used. Some diamonds produced no effect, while another fogged the plate even when the surface of the plate was not scratched by it. With this particular diamond—an ordinary cutting diamond of medium size—the fluorescence became visible when the eye was rendered very sensitive by being kept in darkness for an hour. W. C. H.

REFERENCE.

1651. *Band Spectrum of Nitrogen.* **G. A. Hemsalech.** (Comptes Rendus, 132. pp. 1040–1043, April 29, 1901.)—Tables are given of the wave-lengths of lines measured in the spectrum of air as obtained with an oscillatory electric spark [see Abstract No. 2159 (1900)]. C. P. B.

HEAT.

1652. *Manometer for verifying Boyle's Law.* **Rayleigh.** (Roy. Soc., Proc. 68. pp. 92–93, March 25, 1901 (Abstract); and Roy. Soc., Phil. Trans. 196. pp. 205–223, March 16, 1901.)—This is a description of a new form of manometer, and an account of the author's investigation of the law of the relation between volume and pressure of gases at low densities. The pressures examined are 0·01 to 1·5 mm. of mercury. The method and results of Amagat and of Bohr are stated; but the divergence from Boyle's law, recorded by Bohr in the case of oxygen, is called into question. Bohr states (Wied. Ann. vol. 27 p. 479, 1886) that at temperatures between 11°C. and 14°C., the relation between volume and pressure for pressures greater than 0·70 mm., in the case of oxygen is $(p + 0{\cdot}109)v = k$, but that for smaller pressures $(p + 0{\cdot}070)v = k$, thus indicating a change of condition of the substance. Rayleigh finds no such discontinuity.

The manometric measurement consists in adjusting the levels of two mercury surfaces with respect to two fixed points. The mercury is contained in a glass Y-tube, the stalk of which terminates in a flexible tube communicating with a mercury reservoir. Bulbs are blown, one in each arm of the Y, and each bulb has within it a fixed glass pointer, the ends of the pointers being respectively at the centres of the bulbs. The two arms of the Y are closed at the top; they are approximately of equal length, but one of them is bifurcated. There are thus formed three supports, whose slightly rounded ends carry a mirror platform of worked glass. The axis about which the apparatus can be turned is horizontal and parallel to the face of the mirror, so that the sine of rotation of the mirror from the zero of a fixed scale, as read by a telescope, indicates the difference of levels of the mercury surfaces when these are adjusted to the points in the bulbs. By taking into account the distance between the two fixed points, the readings can be reduced to absolute measure. In the present apparatus the distance between the points is 27·3 mm., and a difference of 1 mm. of level between the two mercury surfaces is represented by 231 mm. of the fixed scale. The greatest pressure that could be dealt with was in these experiments about 1·5 mm.

Connection with the rest of the apparatus is made by branch tubes, one from each bulb. The author finds that the requisite flexibility for this purpose can be attained by the use of a sufficient length of glass tubing between the manometer and the parts which cannot turn with it. This is specially of advantage in cases where indiarubber tubing would lead to difficulty. Full details are given of the method of using this apparatus for verifying Boyle's law, and tables are appended showing the behaviour of nitrogen, hydrogen, and oxygen. So far as the present results can settle the question, the author considers that they justify to the full the ordinary use of the McLeod gauge within the limits 1·5 and 0·01 mm. of mercury. The manometer is capable of measuring small pressures to about 0·002 mm. of mercury. R. A.

1653. *Overcooling of Floating Drops of Nitrotoluene.* **P. Bachmetjew.** (Acad. Sci. St. Pétersbourg, Mem. 10. pp. 1–63, 1900.)—Drops of *p*-nitrotoluene (m.p. 54°) were suspended, usually 10 at a time, in an aqueous solution of calcium chloride, and the time and temperature at which solidification took

place were observed. The degree of overcooling of 10 groups of 10 drops, each weighing 0·0328 gramme was found to vary from 8·5° to 29·2°. The degree of overcooling reaches a maximum at a definite rate of cooling, which was found to lie between 0·60° and 0·55° per minute at 50°. When the number of drops was increased the first drop usually solidified at a higher temperature and the last drop at a lower temperature; with 100 drops, each weighing 0·00824 gramme, 21 remained liquid at 23·9° after 20 hours, and 9 were still liquid at 22·5° after 44 hours. As the size of the drops decreases the degree of overcooling under similar conditions increases, and the amount of overcooling was found to be inversely proportional to the radius of the drops when the weight of each was less than about 0·05 gm., and the radius less than about 2·4 mm. T. M. L.

1654. *Latent Heats of Evaporation of some Organic Nitrogen Compounds.* **L. Kahlenberg.** (Journ. Phys. Chem. 5. pp. 284–288, May, 1901.)—The following determinations have been made :—

	C	p	t	L	ML/T
Amyl amine	0·6136	723	95	98·75	23·3
Dipropyl amine	0·5972	745	108·25	75·69	20
Diisobutyl amine.....	0·5706	735	134·5	65·85	20·8
Valeronitrile	0·5199	741	129	95·95	19·8
α-Picoline	0·4342	745	129	90·75	21

C is the mean specific heat of the liquid of molecular weight M, and L the latent heat of evaporation at temperature $t°$ C. (or T absolute) under pressure p mm. of mercury. The last column indicates that the molecules of liquid amyl amine are somewhat polymerised, whereas those of the other substances when liquid are simple. [See Abstract No. 1498 (1901).] R. E. B.

1655. *Monatomic Gases.* **D. Berthelot.** (Soc. Franç. Phys., Bull. 167. p. 4, 1901.)—Kinetic considerations led Clausius to assign $\frac{2}{3}$ as the ratio of the isopiestic and isometric specific heats of a perfect gas, but this is found to be true only if the gas is monatomic. Similar considerations led van der Waals to give $\frac{8}{3}$ as the value of RT/pv at the critical point, but this is not true for polyatomic gases, as shown by the following values :—

Octane	3·86	Pentane.....	3·76	CO_2.....	3·61
Heptane	3·85	Benzene	3·75	N_2	3·53
Ether.....	3·81	CH_4	3·67	O_2.....	3·49

But for monatomic argon $p_c = 52·8$ atm., $T_c = 155·6°$, $d_c = 0·434$ (as calculated by Mathias' formula for the ratio of the gaseous and liquid densities), so that the ratio is 2·62, which is in accordance with the theory. For polyatomic gases, therefore, van der Waals' characteristic needs modification, the covolume doubtless depending on the number and movements of the atoms in the molecule.

Attention is drawn by **Cornu** to the asymptotic trend of the above numbers as the molecules increase in complexity. R. E. B.

1656. *Thermal and Dynamic Coefficients.* **G. H. Burrows.** (Journ. Phys. Chem. 5. pp. 233–238, April, 1901.)—The relations between Trevor's thermal,

sub-thermal, dynamic, and sub-dynamic coefficients [see Abstract No. 71 (1900)], given by—

$$\begin{aligned}
\theta d\eta &= B_\theta dv + C_v d\theta = C_p d\theta + A_\theta dp = A_v dp + B_p dv \\
-\eta d\theta &= E_\eta dv + F_v d\eta = F_p d\eta + D_\eta dp = D_v dp + E_p dv \\
-p dv &= J_\eta d\theta + K_\theta d\eta = K_p d\eta + I_\eta dp = I_\theta dp + J_p d\theta \\
v dp &= M_\eta d\theta + N_\theta d\eta = N_v d\eta + L_\eta dv = L_\theta dv + M_v d\theta,
\end{aligned}$$

are investigated; the results (which are purely geometrical) may be written—

$$\begin{aligned}
A_v/A_\theta = E_p/E_\eta = J_\eta/J_p &= N_\theta/N_v \\
B_p/B_\theta = D_v/D_\eta = K_\theta/K_p &= M_\eta/M_v \\
C_p/C_v = F_v/F_p = I_\theta/I_\eta &= L_\eta/L_\theta
\end{aligned}$$

R. E. B.

1657. *Calculations of Isothermals.* **C. Dieterici.** (Ann. d. Physik, 5. 1. pp. 51–88, May 4, 1901.)—Calculations founded on Young's experimental results for isopentane lead the author to assume (1) that a gas would have a characteristic of the form $P = Rt/(v-b)$ if its molecules exerted no action on each other; (2) that, if under these circumstances it expanded at temperature t from volume v till its pressure fell to p, the pressure actually exerted at volume v in consequence of the actual attractions between its molecules, the work done would be of the form $RS/vt^{\frac{1}{2}}$, where S is a constant; (3) that the co-volume b is of the form $2\beta - \beta^2/v$, so that $P = Rtv/(v-\beta)^2$. These assumptions give the characteristic—

$$p = RtV/(V-\beta)^2,$$

where—

$$\log\{(V-\beta)/(v-\beta)\} - \beta/(V-\beta) + \beta/(v-\beta) = S/vt^{\frac{3}{2}}$$

whence at the critical point $v_\kappa = 3\beta$, $t_\kappa = (4S/27\beta)^2$.

For large values of v we might take b constant, then obtaining—

$$p(v-b) = Rt\, exp(-S/vt^{\frac{3}{2}}).$$

[But this would give $v_\kappa = 2b$, $t_\kappa = (S/4b)^2$.]

If v_1 and v_2 are the volumes of saturated liquid and vapour at temperature t, $\int_{v_1}^{v_2} P dv$ will be equal to the latent heat of vaporisation $t(v_2 - v_1)dp/dt$, whence—

$$v_1 v_2 t^{\frac{3}{2}} dp/dt = RS,$$

which relation is well satisfied by isopentane and benzol, and fairly by ether, SO_2, and CO_2, and by water at temperatures above 220° C.: the latent heat too is given by—

$$Rt\left[\log\{(v_2-\beta)/(v_1-\beta)\} - \beta/(v_2-\beta) + \beta/(v_1-\beta)\right],$$

an expression already found otherwise by Milner [but for the *internal* and not for the *total* latent heat, as here.]

R. E. B.

1658. *Second Law of Thermodynamics.* **N. Schiller.** (Ann. d. Physik, 5. 2. pp. 313–325, May 29, 1901.)—The author bases the Second Law of Thermodynamics on the general notion of the thermal connection between bodies. Defining the thermal parameters of a body as those quantities whose changes can stand in functional relation with its temperature changes, he treats bodies as in thermal connection if the parameter changes of one body are in functional relation with those of another; the change of state of a

body is adiabatic if its parameter changes occur independently of those of other bodies. From a consideration of reversible changes he derives the entropy function as a function of reversible thermal parameters of a body, which remains constant while the thermal state of the body changes in reversible adiabatic ways. He proves $dQ = \theta dS$, where Q is a quantity of heat, S the entropy function, and θ either a constant or the same function of the temperature only for all bodies, and deduces for reversible changes the relation $d\delta - dL = \theta dS$, $d\delta$ and dL being the change of internal energy and the corresponding work done by the external forces. Equations of condition are deduced from the consideration of $\theta dS + dL$ as a perfect differential. W. E. T.

1659. *Statical Theory of Radiation.* **J. D. van der Waals, Jr.** (Phys. Zeitschr. 2. pp. 461–462, May 4, 1901.)—The author seeks to explain radiation phenomena in a manner similar to that in which Boltzmann has treated the gaseous state. His method differs from Planck's in that he applies the probability law to an aggregate of radiating molecules; considering in an element of space an aggregate of molecules radiating to an external point (P), we see that the electric moments of the molecules are as probably in one direction as in the opposite, but, for radiation to reach P, deviations must occur from the most probable distribution of the moments of the molecules; these and the electromagnetic force at P vary as $\sqrt{n}$, n being the number of the molecules. This is only valid for the most probable force (f), the probability that the force lies between f and df being $ae^{-\frac{f^2}{f_1^2}}df$. This deduction is based on the assumption that the vibrations are independent of one another, but because of absorption a partial arrangement must exist in the molecular vibrations. The author points out the necessity of seeking for the law of this arrangement; he shows that it involves attractive forces between the molecules, and suggests the possibility of thus explaining molecular attraction. W. E. T.

1660. *Irreversible Radiation Processes.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 25. pp. 544–555, May 9, 1901.)—In his previous papers on this subject [see Abstract No. 1701 (1899)] the author gave a definition of electromagnetic entropy in an electromagnetic field in which there are resonators, and he proved that the function so defined can only increase in value until it reaches a certain maximum, and that is when the energy has the same value for each resonator, and at all points in the field. And from this he deduced the relation between radiation and temperature, showing that his results lead to a distribution of energy throughout the spectrum agreeing with that of Wien. Later researches of Beckmann, Pringsheim, and others have shown that Wien's law requires modification for all except very short wave-lengths at low temperatures. The author claims now to have found an expression for the entropy which leads to results in accordance so far with experiment, as well as with certain of Boltzmann's theorems in the Kinetic Theory of Gases. Reference is made throughout to the author's previous paper. The entropy of a resonator according to that paper was $S = -U/a\nu\,(\log U/b\nu - 1)$, where U is the energy of the resonator, ν its frequency of oscillation, and a, b are constants. He now uses the more general form $S = k\left\{(1 + U/h\nu)\log(1 + U/h\nu) - \frac{U}{h\nu}\log\frac{U}{h\nu}\right\}$, which agrees with the former for high frequencies. Here h, k are universal positive

constants. The intensity of entropy radiation receives a corresponding new definition agreeing with his former one for short waves. He then proves that with this new definition the entropy increases to a maximum. Then he identifies the electromagnetic entropy with that of thermodynamics, and defines the temperature θ of a monochromatic resonator having energy U by the expression $\frac{1}{\theta} = \frac{k}{h\nu} \log\left(1 + \frac{h\nu}{U}\right)$, with corresponding definition for monochromatic radiation in space. And he obtains for the whole energy of radiation per unit of volume the value, $u = 48\pi\epsilon k^4 \theta^4/c^3h^3$, where c is the velocity of light, and ϵ stands for the series $1 + \frac{1}{2^4} + \frac{1}{3^4} + \&c. = 1{\cdot}0823$. An example is given of "the temperature of homocentric radiation," referring to a previous paper in Ann. Phys. 1. p. 734, 1900. [Abstract No. 1446 (1900).] S. H. B.

1661. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 37. pp. 91–99, May 3, 1901.)—In an irreversible or partially irreversible cyclic process, Clausius' inequation gives—

$$\int \frac{dQ}{T} > 0.$$

It is here understood that not only T, but all the normal variables of the system, come at the end of the process to their initial values. It appeared from the author's researches that this inequation cannot be extended to permanent changes in its complete generality. This is shown by an example.

The writer had previously proposed a restricted form of the theorem, namely, that not only T and the normal variables, but also the corresponding forces, must return to their initial values. This is now shown to lead to results inconsistent with the known theory of hysteresis.

It is necessary, then, either to reject the author's modified Clausian theorem, or else still further to restrict its generality. With this view the author considers the question, in what cases Clausius' inequation can be extended to permanent changes. He concludes that Clausius inequation is true for pseudo-reversible processes and for so-called isobaric processes, in which the forces are constant. Further, it is true for isothermal processes in which not only the system itself but also the external forces return to their initial values. But whereas he had obtained as the condition for stability that a certain function of the normal variables, namely $\phi(\alpha, \beta \ldots \lambda)$, should be a minimum. He now rejects the proof formerly given of this theorem, but holds to the theorem itself in the following form: We consider a system in which the temperature T and the normal variables α, $\beta \ldots \lambda$ vary within very narrow limits. Then in order that a natural state should be stable with these variables, it is sufficient and necessary that $\phi(\beta \ldots \lambda)$ should be a minimum. [See further Abstract No. 82 (1901).] S. H. B.

REFERENCE.

1662. *Mechanical Equivalent of Heat.* **T. Barnes.** (Elektrochem. Zeitschr. 8. pp. 67–68, June, 1901. From the Oesterr. Zeitschr. für Elektrotechnik. 49. p. 590, 1900.)—A paper similar to that referred to in Abstract No. 1879 (1899). W. E. T.

SOUND.

1663. *Vibration of Air-Sheets.* **V. Hensen.** (Ann. d. Physik, 4. 1. pp. 41–59, n., 1901.)—In further elucidation of the manner in which a mass of ibrating gas transfers its vibrations to another mass separated from it by a aseous sheet acting like an incompressible fluid [see Abstract No. 2196 900)], the author reproduces photographic records of the vibrations of nsitive flames placed in front of the lips of organ-pipes. He finds a certain egree of independence between the wave-length of a vibrating column of air id the pitch of the note. A parallel case is that of the siren, which gives the me pitch whether it is blown strongly or softly. E. E. F.

1664. *Transmission of Sound through Porous Materials.* **F. L. Tufts.** mer. Journ. Sci. 11. pp. 357–364, May, 1901.)—The porous materials used ere cylindrical vessels filled with shot of various sizes. The coarsest aterial was shot 4·37 mm. in diameter, the next 2·79 mm. in diameter, id the third 1·22 mm. in diameter.

The question under consideration is, whether if two materials differ aterially in the resistance offered to the transmission of sound they also ffer in the same way in the resistance offered to the flow of a current of air rough them.

To study the resistance offered to the flow of air through the material the ot is placed in a glass cylinder 75 cm. long, and 2·5 cm. internal diameter, osed at the bottom with a piece of wire gauze, and there connected with a as meter, to measure the amount of air which passes through, and a mano- eter to register the pressure. The top of the tube is in connection with a as-holder and another manometer, so that the difference of pressure of the as before and after passing through the shot can be measured.

The lengths of the columns of shot were made equal to 10, 20, and 0 cm., successively, and the pressures 1, 2, and 3 cm. of water, and it was und that the time taken for a given volume of air to flow through was in ch case the same; hence the resistance is directly proportional to the ickness of the material used. Experimenting with successively increasing fferences of pressure, it was found that the rate of flow increased less pidly than the pressure, and that this was more noticeable with the coarse an with the fine shot.

A series of experiments was then undertaken to ascertain if the same riation in the resistances of these substances to the transmission of sound aves existed. A thin rubber membrane was stretched on a brass ring and t into a circular opening in a piece of wood; the opening was closed above y having a cylindrical vessel placed upon the top of it, with a wire gauze ottom, in which the shot were placed. The opening was not closed below, but as exposed to the air. To the centre of the membrane was attached a rectan- ular piece of tin-foil, standing perpendicularly to its surface, in which a trans- erse slit was made, so that the amplitude of vibration of the membrane could be tudied by observing the width of the slit with a microscope, a strong light eing placed behind it. An organ-pipe, whose pitch could be varied, completed he apparatus. The organ-pipe, being tuned to the fundamental note of the membrane, was blown, and shot added centimetre by centimetre, the ampli- ude of vibration being measured at each addition; the differences of the

reciprocals of the amplitudes should theoretically be proportional to the resistance offered by the various thicknesses of shot.

The results bear out the following law : That the resistance offered by granular material to the to-and-fro motion of a sound wave is proportional to the thickness of the material, other things being equal. Hence the relation between the resistance and the thickness is the same as holds for direct currents of air. W. C. O.

1665. *Rating Tuning-forks.* **J. O. Reed.** (Phys. Rev. 12. pp. 279–291, May, 1901.)—The arrangement employed is the following : A rod 8 mm. in diameter and 1 metre long is suspended by two pieces of clock spring, and at the lower end are attached a large lens-shaped piece of lead and four adjustable weights. Below the middle of the rod is clamped a ring, which carries a short arm, to which a small needle is attached so as to be parallel to the rod. Against this needle rests a fine glass tube about 0·1 mm. in diameter, attached normally to a vertical axis which carries a plane mirror. As the pendulum swings the mirror is caused to rotate about its axis through a relatively large arc. The glass tube is held against the needle by means of a drop of oil whose viscosity is sufficient to carry the mirror with it on its return swing. Light from a slit is focussed on this mirror with a lens, and thence passes through an aperture in the side of a collimating telescope placed at some distance, and, striking the base of a right-angled prism in the telescope, passes down it and out of the objective as a parallel beam. To the end of the fork to be rated is fixed a mirror ; the fork is placed so that this mirror may catch the beam and reflect it once more into the telescope, where its motions can be observed by the eye. If the pendulum vibrate, the image flashes into the field of vision each time the image sweeps past the window in the telescope. When the fork is in motion, also, the image becomes a stroboscopic procession of images crossing the field. In making an observation the pendulum and fork are started and the length of the pendulum adjusted until there are between 5 and 10 flashes in the cycle. The coincidence of the flash with the cross-wire of the telescope is awaited and the flashes counted continuously, the coincidences being noted and those particularly sharp underlined. Observations are made upon the period of the pendulum at the same time. If it is not convenient to attach a mirror to the fork the flashes may be observed through a low-power microscope focussed sharply upon the prong of the fork so that it obscures about one-half the field of vision. Stroboscopic shadows are then obtained when the fork vibrates instead of the images of the slit observed in the other method. The fork may be shielded in a metal case from changes of temperature, a small hole being left for the ingress and egress of the beam of light. Numerical results are given which seem to justify the assumption that the method will give the frequency-constant to the third decimal place. A pendulum is described whose period can be altered at will while in motion by allowing mercury to leave it in a fine stream, regulated by a small stopcock with a long handle that can be turned with a touch of a pencil. W. C. O.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1666. *Duality in Electrical Theory.* **H. Sire de Vilar.** (Écl. Électr. 27. pp. 252–259, May 18, and 278–285, May 25, 1901.)—In geometry the method of reciprocal polars enables us, having given a theorem concerning points and planes, to deduce a reciprocal theorem concerning lines and points. This reciprocal relation is termed the principle of duality. The author in this paper develops reciprocal relations in electrical theory. For example, the reciprocal of the theorem that the total resistance of conductors in series is the sum of the separate resistances is that the total conductance of conductors in parallel is the sum of the separate conductances. He writes the general equation of an electric circuit in the form—

$$E_1 + E^{\epsilon} + RI = 0,$$

where E_1 is the internal counter e.m.f., E the external counter e.m.f., and RI the external ohmic drop. Dividing this equation by R, and denoting $\frac{E_1}{R}$ by I_1 and $\frac{1}{R}$ by K, we get—

$$I_1 + I + KE = 0.$$

These two equations are reciprocal theorems. The second follows from the first by writing I_1 for E_1, I for E, and K for R. The equations can also be written in the form—

$$EI + E_1I + RI^2 = 0,$$
$$EI + EI_1 + KE^2 = 0;$$

and this suggests the idea of reciprocal circuits which the author investigates for the case of shunt and series dynamos and motors. The third equation given is—

$$E_1I_1 + E_1I + EI_1 = 0,$$

which is its own reciprocal. In this paper the author discusses direct current theory only, but in a future paper he will show that the principle can be usefully applied to the theory of alternating currents. A. R.

1667. *Mechanical Representation of Electric and Magnetic Phenomena in Bodies not in Motion.* **L. Graetz.** (Ann. d. Physik, 5. 2. pp. 375–393, May 29, 1901.)—The author considers that the old dual theory of electrostatics and electromagnetics is not to be regarded as obsolete, notwithstanding the theories of Maxwell, Hertz, and their followers. The introduction of ions goes far to re-establish it. In the present paper he assumes ether to be an elastic solid capable of compression or distortion. The density ρ_1 and the abstract constant R are different for different substances. Of the second constant of electricity θ, magnetic phenomena teach us nothing. If ξ, η, ζ be the components of ether displacement, and $\sigma = \frac{d\xi}{dx} + \frac{d\eta}{dy} + \frac{d\zeta}{dz}$, then the fundamental equations for free ether are as usual—

$$\rho \frac{d^2\xi}{dt^2} = K \cdot \left(\Delta\xi + (1 + 2\theta)\frac{d\sigma}{dx}\right), \text{ \&c.}$$

The displacement of an ether particle may be either dilatational ξ', or rota-

tional ξ'. Every volume-element of ether is supposed to have a ponderable nucleus which resists its dilatation. On the other hand, the dilatations of ether cause relative displacements among the nuclei. The pressure p satisfies the equation—

$$p = 2K(1 + \theta)\sigma,$$

whence is found for the components X, Y, Z of force—

$$X = -\frac{dp}{dx} = -2K(1 + \theta)\frac{d\sigma}{dx}$$

$$Y = -2K(1 + \theta)\frac{d\sigma}{dy}$$

$$Z = -2K(1 + \theta)\frac{d\sigma}{dz}$$

In a conductor the decay of the displacements depends on the conductivity λ', and gives rise to the form $-4\pi\lambda'\frac{d\xi}{dt}$.

Hence the author finds the equations of motion in the form—

$$\rho\frac{d^2\xi}{dt^2} + 4\pi\lambda'\frac{d\xi}{dt} = K\left\{\frac{d}{dz}\left(\frac{d\xi}{dz} - \frac{d\zeta}{dx}\right) - \frac{d}{dy}\left(\frac{d\eta}{dx} - \frac{d\xi}{dy}\right)\right\}.$$

If L', M', N' denote the components of magnetic force, we have—

$$L' = K\left(\frac{d\zeta}{dy} - \frac{d\eta}{dz}\right)$$

with corresponding equations.

The following conclusions are drawn. In a vacuum ether behaves as an elastic body, to which we can attribute the properties given by Fresnel and Neumann. In ponderable bodies action takes place between the disturbed ether and the molecules. The action of the ether on the molecules is the electrostatic force, and those parts of a substance where it continues to exist are ions. This action and reaction between molecules and intermolecular ether is expressed by Maxwell's six equations. Magnetic polarisation consists in the torsion of ether. The electric forces, other than the electrostatic, consist in the translation velocities of ether. The magnetic energy is the potential energy of the included ether. The electric energy consists of two parts—one the kinetic energy of ether, the other the potential of the mutual action of matter and ether. The so-called true magnetisation has no existence and no meaning. True electrification is the excess of the included ether above the normal. An electric current in a conductor is not an ether phenomenon, but a molecular phenomenon, consisting in the motion of molecules. The conductivity of a substance is closely related to, but not identical with, its heat conductivity and internal friction. The motions of matter and ether are not independent. The theory can easily be extended to explain the phenomena of dispersion. S. H. B.

DISCHARGE AND OSCILLATIONS.

1668. *Conductivity produced in Hydrogen and Carbonic Acid Gases by Motion of Negatively Charged Ions.* **J. S. Townsend** and **P. J. Kirkby** (Phil. Mag. 1. pp. 630-642, June, 1901.)—Continuation of Townsend's earlier experiments [see Abstracts Nos. 2449 (1900) and 1103 (1901)], in which the conductivity produced in air at low pressures was discussed and explained by supposing negative ions to produce others by collisions with neutral molecules these new negative ions having the same properties as those produced at the

tset by Röntgen rays. This collision theory is now further discussed in the ght of these new experiments in which hydrogen and CO_2 gas have been used stead of air. It is shown that the value found by Townsend for the energy quired to ionise a molecule is very much smaller than that given by Ruther- rd and McClung [see Abstract No. 797 (1901)], whose method is criticised d considered not wholly trustworthy. Tables of results, showing the rrents produced at various pressures and under varying potentials, are ven, and then from theoretical considerations the formula expressing the mber of ions (a) generated by a single ion under electric pressure in passing rough 1 cm. of a gas whose pressure is p, is shown to be of the form—

$$\frac{a}{p}=f\left(\frac{x}{p}\right)$$

is found that a negative ion makes 11·5 collisions per cm. in hydrogen at mm. pressure, and 29 per cm. in CO_2 gas at the same pressure. Comparing ese values and that for air with the collisions of molecules as given by the netic theory, it is seen that the mean free path of an ion is longer than that a molecule in the following ratios :—

4·8 : 1 in H_2 ; 4·6 : 1 in CO_2 ; 4·3 : 1 in air. W. C. H.

1669. *Change of Colours of Cloudy Condensation with Number of Available Nuclei, and Effect of Electric Field.*—I. **C. Barus.** (Phil. Mag. 1. pp. 572–8, May, 1901 ; see also Phil. Mag. [5] 38. pp. 19–35, 1894.)—The nuclei e produced by passing air through a tube containing pellets of phosphorus, d the stream of air is then admitted within a cylindrical steam-jet, and the lour of the condensation produced observed. This colour depends upon e rate of admission of the charged air, and a blue colour, produced by itre of air per minute, is taken as a standard. The results are given in tabular rm and plotted on a curve. If the charged air is made to pass through an ectric field before admission to the steam-jet, the volume of air passing per cond bears a constant ratio to the electrical current passing for a constant tential-difference between the plates of the condenser producing the field ; that, with proper graduation, the colour obtained is a measure of the rrent in the condenser. Using a slender tubular condenser, with distance 141 cm. between outer and inner electrodes, the author has found that for tential-differences of 60, 150, and 300 volts, and for all available colours, no ace of colour fluctuation in the steam-tube is to be observed, and he concludes at, unless the nuclei producing current are different from those producing ndensation, the number removed by the current is insignificant as compared th the total number present. W. C. H.

1670. *Effect of a Tesla Coil on Nitrogen.* **H. Kauffmann** and **B. Hell.** hys. Zeitschr. 2. pp. 476–478, May 11, 1901.)—Nitrogen is allowed to stream rough an apparatus very similar to an ozoniser, the inner and outer surfaces ing connected to a Tesla coil. The tube is found to be filled with a bluish ht, and the glass fluoresces yellowish green. When the gas stream is pped the sparks become rose-coloured, and this colour spreads all over the be to the exclusion of the blue and the colour of the phosphorescing glass. restarting the flow of gas the appearances take place in the inverse order. th blue and red lights give a line and band spectrum. Various minerals aced in the tube were found not to phosphoresce ; some, however, showed strong thermo-luminescence when used in the form of solid solutions.

R. S. W.

1671. *Kathode Rays.* **P. Villard.** (International Physical Congress a Paris, Report, 3. pp. 115–137, 1900.)—A systematised historical *résumé* of the leading facts. The author concludes from the reducing action of kathode rays being the same whatever the nature of the gas in the tube, and whatever the kind of kathode flux, and from the relation e/m being always the same that radiant matter is always the same; and as it is a reducer, and as the spectrum of hydrogen is always present, often alone, in the luminescent layer which marks the afflux at the kathode, he considers it probable that this radiant matter is hydrogen. A. D

1672. *Kathode Rays and the Constitution of Matter.* **J. J. Thomson** (International Physical Congress at Paris, Report, 3. pp. 138–151, 1900.)—The ratio e/m is much larger (about 10^7) in kathode ray corpuscles than the same ratio in electrolysis of liquids (about 10^4). The value of e is independent of the nature of the gas, and is about $6{\cdot}10^{-10}$ electrostatic units, which is of the same order as the charge of an ion of hydrogen in electrolysis. Therefore m the mass of each corpuscle, in the case of kathode rays is about $\frac{1}{1000}$ that of the atom of hydrogen. We have therefore a new state of matter, consisting of subatomic corpuscles, invariable in mass from whatever material they be derived and in whatever manner they be produced. Each of these corpuscles carries a fixed charge of negative electricity: positive electricity seems to be always borne by ordinary matter. The positive particles in a vacuum tube present the same e/m as in ordinary electrolysis. The corpuscular condition is presented not only in kathode and Lenard rays, but also in the neighbourhood of a metal plate under ultra-violet light, in that of a filament incandescent in a very high vacuum, and in the radiations from radium and other radio-active substances. But more than this, it is, the author thinks, much more widely spread: it exists throughout metals, which seem to owe their conductivity to it, the corpuscle detached from an atom being negatively and the remainder of the atom positively charged, and fresh corpuscles being continuously formed as former ones are reabsorbed, so that the steady state is one of statistical equilibrium. The negatively charged corpuscles move easily, the positively charged remainders less so; but the corpuscles do not emerge from the mass unless their kinetic energy exceeds a limit, since work would have to be expended in separating them from the conductor. Under an electric force, the corpuscles in the metal move in an opposed direction they thus carry a charge, and the metal appears to carry current. If they travel to a cooler part of the metal, they carry kinetic energy with them; whence thermal conductivity. If this be so, we could calculate the ratio of the thermal to the electric conductivity: the calculated ratio is fairly in accordance with facts, but the calculation is not quite conclusive in favour of this theory, and the actual ratio is not exactly the same in all metals, as it should be if the corpuscles alone carried all the electricity and all the heat. The gaseous pressure of corpuscles in bismuth works out at about $\frac{1}{4}$ atmosphere and in copper or silver at thousands of atmospheres. Each molecule of bismuth seems to shed and reabsorb corpuscles about 40,000,000 times per second on the average: molecules of other metals much oftener than this. The collisions which determine the free path of the corpuscles seem to be those between the corpuscles and neutral atoms. If the acceleration produced by an electric force is great in comparison with the actual velocity, Ohm's law ceases to apply: in the limit the current becomes proportional to the square root of the electric force. With alternating currents in bismuth, the conductivity would disappear when the wave-length fell below 4 mm. In a

magnetic field, the corpuscles would describe arcs of a spiral instead of straight lines; with results, in the case of bismuth, showing a diamagnetic constant larger than the actual one but of the same order of magnitude and within the limits of uncertainty of the data. The impact of corpuscles upon molecules is slow in comparison with that of kathode rays; we would therefore expect not Röntgen rays but, say, calorific radiations. Corpuscles could not leak away from the metal: if one did it would leave the metal positively charged and would be attracted back: consequently there is a double film at the surface of the metal, negatively charged on the outside and positively on the inside: and for any corpuscle to get through this double film would require as much energy as would be acquired by a corpuscle passing from the high internal to the low external pressure. The energy of the corpuscles, and their tendency to quit the metal, increase with the temperature. In non-conductive compounds of the metals, the atoms of the metal already have a positive charge on account of previous loss of corpuscles. The theory explains bismuth: but for those metals in which the Hall effect and the specific heat of electricity are opposed to those of bismuth, something beyond these corpuscles is necessary; possibly positively charged corpuscles, though we have no evidence of the existence of these. The paper concludes with an investigation of the differential equations for the distribution of the corpuscles in the metal.

A. D.

1673. *Reflection of Kathode Rays.* **E. Gehrcke.** (Preuss. Akad. Wiss Berlin, Sitz. Ber. 20. pp. 461–467, April 18, 1901.)—Experiments are described showing that there is a loss of velocity upon reflection which is revealed by the greater extent to which a fluorescence-patch is displaced by a magnet. Merritt had come to a negative result. The reflected rays were retarded by a small thickness of metal, a greater thickness of which would have absorbed them. The amount of retardation depends correspondingly upon the metal of the reflector.

A. D.

1674. *Canal Rays in Rarefied Gases.* **W. Wien.** (Ann. d. Physik, 5. 2. p. 421–435, May 29, 1901.)—A continuation of the author's work on the subject. [See Abstract No. 1287 (1900).] Many experimentalists have advanced theories of the canal rays on the supposition that they emanate from the kathode. Wien points out that they must start from the anode, for if a hole is bored through the kathode they pass through in more or less straight lines. By observation of the deflection due to a magnetic field and the heating effect on a bolometer, the ratio e/m is found, and also their velocity. A large portion of the paper is devoted to the calculation of the magnetic deflection when the field is not uniform. When the observations are made, it is found that the deflection of different parts of the stream varies from a small fraction of a mm. up to 2 centimetres, and this although great care had been taken to render the gas pure. This gives values of e/m varying from 10·1 to 36,360. The fluorescence excited on the glass is due almost entirely to the rays having the mean deflection by the magnetic field; those having a large or a small deflection are almost without influence.

R. S. W.

1675. *Faraday's f-Surface.* **A. Korn.** (Ann. d. Physik, 5. 1. pp. 136–139, May 4, 1901.)—When two electrodes are arranged at from 1 to 3 cm. apart in a vacuum tube (0·3 to 0·7 mm. pressure) and are both connected with the negative pole of an influence machine or inductorium, then if the

arrangement is quite symmetrical a very bright sheet of glow is seen in the tube, midway between the electrodes. The edges of this sheet make a very bright and narrow ring of light round the bulb. If the connection of one of the electrodes is made of higher resistance, the glow shifts towards that electrode and becomes hyperboloidal instead of plane, being hollow towards that electrode. Various experimental modifications of form of this glow are described, and the conclusion is reached that Hertzian oscillations propagated in the electrodes cause radiation of negative charges, more intensely the stronger the oscillations : so that what ultra-violet rays, Röntgen rays, and Becquerel rays can do in the ordinary atmosphere, ordinary Hertzian oscillations, from sparks, can do at 0·3 to 0·7 mm. pressure. A. D.

1676. *Influence of Electric Waves on Selenium.* **A. Masini.** (N. Cimento, 1. pp. 358–359, May, 1901.)—Experiments made with all precautions against error lead to the conclusion that electromagnetic waves have no influence upon the resistance of crystallised selenium. E. E. F.

1677. *Velocity of Electric Waves along Wires.* **C. G. Barkla.** (Phil Mag. 1. pp. 652–657, June, 1901.)—A Hertzian oscillator and a Lecher's system of wires were used, the exhausted tube used by Lecher being, however, here replaced by a Rutherford's detector. By this means the wave-lengths were compared when the thickness or material of the wires in the Lecher circuit was changed. When the material was copper a change of diameter from 0·076 cm. to 0·0036 cm. reduced the wave-length about 1·8 per cent. When the wires were changed from copper of 0·015 cm. diameter to platinum of 0·0158 cm., the wave-length was reduced by about 0·37 per cent. E. H. B.

1678. *Electric Oscillation Experiment.* **H. Pellat.** (Comptes Rendus, 132. pp. 1178–1180, May 13, 1901.)—By means of a large and small condenser and a high-insulation reversing key, a spark discharge may be obtained, although the initial potential-difference was only half that required for sparking. This result, at first sight paradoxical, is explained on the theory of electrical oscillations, for it is shown that the maximum potential-difference obtainable at the terminals of the small condenser approaches three times the initial potential-difference as the ratio of the capacities of the two condensers is made to increase without limit. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1679. *Hall's Phenomenon in Mercury and Bismuth Amalgams.* **A. Amerio.** (N. Cimento, 1. pp. 342–355, May, 1901.)—Amaduzzi and Leone concluded from their experiments [Abstract No. 1850 (1900)] that bismuth amalgams showed the Hall effect, while mercury did not. The author notes that they did not observe the effect of reversing the current, and thinking that this threw some doubt on the accuracy of their conclusions he repeated their experiments.

He found that on reversing the current the galvanometer current from the cross-electrodes did not reverse, showing that the effect could not be due solely to a Hall phenomenon. The paper describes fully a number of experiments made with the view of finding the causes of this effect ; the conclusion arrived at is that what Amaduzzi and Leone attributed to Hall's phenomenon is due to a Lippmann effect, namely, to the lateral motion of the amalgam conductor, which, unless the field be exactly uniform and symmetrical, will

hange the equipotential lines. He verified this conclusion by introducing a ubble of air into the cell containing mercury; under the action of the field his was displaced. He concludes that bismuth amalgam does not show a Hall effect with a coefficient of 0·00004, the lowest value susceptible of measurement by his apparatus. G. H. B.

1680. *Thermo-magnetic Longitudinal Effect.* **L. Lownds.** (Ann. d. Physik, .. 4. pp. 776–787, April, 1901. Abstract in Deutsch. Phys. Gesell., Verh. 3. 1. p. 3–6, 1901.)—A circuit formed out of various metals placed together consists partly of bismuth. The last portion is traversed in one direction by . flow of heat, and is placed in a magnetic field whose lines of force are irected at right angles to the flow of heat. Then the e.m.f. of the circuit epends on the strength of the magnetic field. This is the thermo-magnetic ongitudinal effect discovered by Ettinghausen and Nernst in 1886. The ame phenomenon was observed in 1887 by Grimaldi, and described as hange of the thermo-electromotive force by the magnetic field. Etting-ausen and Nernst, and later Defregger and E. van Everdingen, have ccepted and supported this explanation. The object of the experiments ere described was to find whether a change of the thermo-e.m.f. through he magnetic field actually takes place.

A wire of bismuth of 1 mm. diameter was taken, which, by cooling to the temperature of liquid air, showed about the same increase of specific conductivity as the wire used by Fleming and Dewar.

In these experiments the arrangement was such that a fall of temperature in the magnetic field did not take place, and then, although the magnetic field had various strengths from 4,500 to 8,100 c.g.s., it had no influence on the e.m.f. of the element. According to Kelvin's theory of thermoelectric circuits the field has, under the circumstances, no influence on the Peltier effect or Thomson effect, and thermoelectric constants of the bismuth are left unchanged.

Nernst observed that the e.m.f. p of the longitudinal effect set up by a determined field between two places, 1 and 2, depended only on the temperatures t_1 and t_2 of these places, or, according to Nernst,

$$p = (t_2 - t_1)n.$$

Thus n depends on the strength of field H, and the mean temperature $\frac{1}{2}(t_1 + t_2)$. Hitherto experiments have been conducted within very narrow limits of temperature. Lownds has determined n as a function of H between about $+70°$ and the temperature obtainable through the use of liquid air. He gives the results in a set of curves. It is noticeable on the curve diagram (the abscissæ representing strength of field H, and the ordinates the longitudinal effect), that for a temperature of $-112°$, and a field-strength of 2,450 c.g.s., the longitudinal effect reaches a maximum, then decreases, and would, to all appearance, become negative with a stronger field. The effect was also observed in a plate of bismuth instead of a wire, and here at $-135°$ the effect attains a maximum when H is about 2,000, then decreases, is negative when H = 4,000, and has an increasingly negative value as H is farther increased.

The thermomagnetic transversal effect as investigated fully by Yamaguchi is quite different; with the lowest temperature reached and the strongest fields it continues to increase. J. J. S.

1681. *Photo-electric Currents.* **M. Allegretti.** (Phys. Zeitschr. 2. pp. 317–319, Feb. 23, 1901.)—An account of observations on the e.m.f. produced by the action of light. The source of light was an electric lamp. The light could be varied in intensity, and was placed at various distances from the actinometer. Different substances sensitive to light were used, such as copper sulphide, copper iodide, silver sulphide, and silver iodide. The e.m.f. which originates through the action of light on the metallic surface dipped in an electrolyte remains, for a time which varies with each kind of actinometer, approximately constant, is then variable with a tendency to decrease, and finally completely disappears. In the first period in which the sensitiveness of the apparatus is constant, the e.m.f. called forth by the action of light on plates of sulphide and iodide of copper is inversely proportional to the distance between the source of light and the actinometer. J. J. S.

1682. *Electric Conductivity of Silver Films.* **C. Grimm.** (Ann. d. Physik, 5. 2. pp. 448–478, May 29, 1901.)—It has been found by G. Vincent that thin silver films have a higher specific resistance than silver under ordinary conditions. The author subjects this to further tests, and investigates very fully the influence exercised on the physical properties of the film by the method of silvering; a reduction of the resistance is found to take place with time. The influence of the following factors on the resistance is studied: (*a*) Temperature changes; a large decrease in resistance is found. (*b*) Effect of light; the decrease in resistance found by Lüdtke is shown to be due to the heating effect. (*c*) Passage of an electric current or of electric waves. (*d*) Polish. (*e*) Pressure; as the pressure decreases so does the resistance. (*f*) Washing with various liquids. (*g*) Influence of the surrounding gas. R. S. W.

1683. *Measurement of Large Direct Currents by a Transformer.* **H. J. Ryan.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 265–279, April, 1901.)—The method is based on the fact that the permeability of the core of a transformer is a maximum when the ampere-turns in the primary and secondary coils are equal and opposite. The large direct current to be measured is taken through the secondary, and a direct current is passed through the primary and adjusted till the permeability of the core is a maximum. The primary current is measured, and thus the secondary current is known. The permeability of the core is examined by means of two small test-coils wound on the core: one of these is supplied with alternating current taken from a two-part commutator connected with direct current mains, and the other, acting as secondary, is connected, through a commutator, with a d'Arsonval galvanometer. The deflection of the galvanometer measures the permeability of the core. A specially constructed transformer was used, with very small magnetic leakage; the main coils had 1 turn and 68 turns respectively, and the test-coils 10 turns each. In measuring a fluctuating current of 950 amperes the error was 0·4 per cent. W. H. E.

1684. *Improved Method of Applying the Insulation Overlap Test.* **W. Betts.** (Elect. Rev. 48. pp. 1048–1049, June 21, 1901.)—To obviate the delay and disturbance on the cable, and the consequent errors in localisation of the fault, by discharging, recharging, and rebalancing after each test, and striking a mean of a number of readings taken under varying conditions, the author adopts the substitution method of measurement. At a prearranged moment, the clocks being previously synchronised to a second or less, one observer

takes a reading, and leaves his end of the cable insulated instead of allowing it to earth and discharge, the second observer taking a reading immediately afterwards. The two results form a distinct calculable pair, and similar pairs can be repeated as often as desirable. The charge being retained in the cable with a path of escape only through the fault tends to keep the latter constant during the tests. It is assumed that the fault would be approximately centralised by inserting resistance at the shorter end, and that due precautions with regard to the presence of earth current and reading to cable zero would be observed. E. O. W.

1685. *Localisation of High Resistance Breaks.* **J. Rymer-Jones.** (Elect. Rev. 48. pp. 959–962, June 7, and 1007–1009, June 14, 1901.)—Allowing for the cable current, if any, after making the necessary observations, the author measures the circuit resistance by direct deflections, and also the charge of the circuit. He considers the resistance, R, of the cable conductor and fault as entirely made up of cable having a mean resistance, *r*, per N.M. of the whole cable as laid, and the mean capacity per N.M. as obtained from the factory value. The length of this "imaginary" cable will be $\frac{R}{r}$ or L knots, and the total capacity with the distant end insulated will be Lf_1. If the distant end of the "imaginary" cable be direct to earth, and the potential at the testing end maintained the same as when the distant end was free, the static charge held by the whole length L will be $\frac{Lf_1}{2}$, equivalent to F microfarads distributed in proportion to the falling potential from a maximum at the testing end to zero at the distant end. Tables showing the distribution and sum of the static charges for each unit of this "imaginary" cable have been constructed on the supposition that it is divided into 1,000 equal parts. In reality R is only partly made up of cable conductor, the remaining resistance being in the ruptured end, which has no capacity. The fall of potential is, however, the same, and quite regular throughout the resistance R, equivalent to L knots, whether it be wholly or only partly cable conductor. By measuring therefore the static charge held by the cable portion, and calculating therefrom its capacity *f*, a ratio is obtained between *f* and the calculated total capacity F which the "imaginary" cable would have if L knots long. The values of *f* and F must here be understood to express only the relative capacity of the part and whole of the cable respectively, to hold a static charge under the special conditions of the test. By the aid of this ratio and his tables he is able to locate the distance of the fault from the testing end.

The distance of the break as calculated is strictly correct only when the C, R, and capacity employed for the calculation are the mean per N.M. of the ruptured portion under test. Until the approximate distance is found these will not be precisely known and a correction may be necessary. For instance, part of the cable may be in deep, cold water and part in shallow and warmer water. The author shows how the results would be corrected by the observed or estimated temperatures in this case.

The arrangements for testing are described and best modes of avoiding errors, and the form of galvanometer best suited for the purpose. E. O. W.

1686. *Schuckert's Workshop Apparatus for Measuring Hysteresis.* **J. A. Möllinger.** (Elektrotechn. Zeitschr. 22. pp. 379–381, May 2, 1901.)—In this apparatus the iron to be tested is in the form of thin sheet-iron rings, 0·5 mm. thick, having an internal diameter of 21·9 cm. and an external diameter of

32·3 cm. with five holes. Ten kilos of these rings (about 56) are weighed out and laid together with paper between them on a vulcanised fibre ring with fibre pins in three of the holes. The packet is then placed in a coil of 100 turns, the convolutions of which can be opened to admit the packet. For this purpose, each convolution is divided and the ends united by a plug engaging a socket fixed in an insulating base. The plugs are mounted friction-tight in groups of 10 in blocks of fibre so that, after they have been placed in their sockets together, they can be tightened separately by striking them with a wooden mallet. They can be removed in five groups by forcing similar series of 20 pins mounted on blocks of fibre into the sockets from the other side by means of cams. The packet is then subjected to an induction of 10,000 lines at 50 ∿ and the hysteresis loss measured by a Weston wattmeter having Swinburne and Evershed's compensating coil (see British patent, No. 3942, of 1885), arranged in series with a resistance of such value that the wattmeter only measures the watts used in the iron-testing coil. The pressure across the terminals of the coil necessary to give the standard induction above mentioned is determined once for all, and afterwards reproduced. It was found that a variation of resistance in the plug connections in the testing coil from 0·11 to 0·13 ohm, *i.e.*, 0·02 ohm variation, only caused an error of 1 per cent. C. K. F.

1687. *Astatic Galvanometer.* **M. Lippmann** and **V. Crémieu.** (Comptes Rendus, 132. pp. 1161–1163, May 13, and 1267–1270, May 28, 1901.)—An arrangement described in which a needle, in the magnetic meridian, is urged along the axis of a coil, or two coils, bearing the current to be measured : and a torsion arrangement for measuring the force. This action is not affected by the terrestrial magnetic field, and the arrangement is entirely astatic. **V. Crémieu** has followed this up by a modification which results in an extremely sensitive balance capable of serving as a galvanometer, electrodynamometer, or absolute electrometer. A. D.

ALTERNATING CURRENTS AND MAGNETISM.

1688. *Propagation of Polyphase Currents along a Number of Parallel Wires.* **W. B. Morton.** (Phil. Mag. 1. pp. 563–571, May, 1901.)—Continuing the analytical methods adopted in a previous paper [see Abstracts Nos. 516 (1901) and 1168 (1899)] the author here discusses the cases of polyphase currents of various phase-differences and along cables of different numbers of wires up to 12 wires inclusive. The effective capacity, resistance, and inductance are each dealt with, and the results obtained are exhibited both graphically and in tables. The attenuation is also worked out numerically for typical cases. It is noteworthy that the attenuation for three wires with phase-difference 120° is greater than for two wires with phase-difference 180°, that for four wires with difference 90° is equal to the two-wire value, while that for five with difference 72° is less than the two-wire value. E. H. B.

1689. *Photographic Records of Wave-shapes by means of Braun Tube.* **A. Weinhold.** (Elektrotechn. Zeitschr. 22. pp. 409–411, May 16, 1901.)—The author gives an account of the apparatus used by him for photographing wave-shapes, the oscillograph employed consisting of a Braun tube. For obtaining a displacement of the spot of light in a direction perpendicular to that of the oscillation of the kathode rays, a synchronous motor of

simple construction is employed. Two such motors are described. The first consists of a series of 50 vertical iron pins, each about 3 mm. thick, projecting from the periphery of a shallow cylindrical box filled with water (so as to increase the moment of inertia of the rotor), and of a small electromagnet whose pole-pieces come to within 1 mm. of the circle of iron pins. This electromagnet is supplied with alternating current at about 18 volts. The second form of motor has a stator whose core is made up of 40 sheet-iron stampings 0·5 mm. thick, having an external diameter of 136 mm., and an internal one of 96 mm., and furnished with four inwardly projecting pole-pieces, each about 7 mm. long. The rotor is a cross, similarly built up of 40 stampings, the arms of the cross being 18 mm. wide, and wound with a double layer of bare copper wire 1 mm. thick. The synchronous motor carries a mirror whose rotation produces the required displacement in a direction perpendicular to that of the oscillation. Reproductions of curves obtained in this way are given; the lines are somewhat coarse, and correspond to broad bands of light rather than sharply defined lines. A. H.

1690. *Stroboscopic Methods of Measuring Frequency.* **G. Benischke.** (Ann. d. Physik, 5. 2. pp. 487–488, May 29, 1901.)—The author refers to Samojloff's method [Abstract No. 117 (1901)] of determining the frequency of alternate currents, by illuminating a stroboscopic disc by a lamp fed by the current. When an arc lamp is available, the measurement can be made in daylight; with an incandescent lamp, however, if the frequency be 80 ∼ or over, the room must be darkened. To avoid this the author proposes to observe through a perforated disc, a jet of water issuing from a vessel carried by a bar of iron; the latter serves as armature to an electromagnet fed by the current, and its vibrations, when properly adjusted, cause the jet of water to break up into drops, the frequency of which is equal to that of the current. The velocity of the disc is adjusted to make the drops appear stationary. G. H. B.

1691. *Variation of Hysteresis Coefficient in Sheet-Iron.* **G. Stern.** (Elektrotechn. Zeitschr. 22. pp. 432–434, May 23, 1901.)—The experiments described in this paper were undertaken with a view of determining in how far the hysteresis loss varies over different portions of the same sheet of iron. For this purpose samples were cut and tested by means of a Ewing hysteresis tester. The results show a maximum variation of about 8·8 per cent. from the mean value, and are somewhat irregular, so that no general conclusions can be drawn from the results obtained. A. H.

1692. *Geometrical Study of a Condenser Transformer.* **E. Perreau.** (Journ. de Physique, 10. pp. 332–336, May, 1901.)—This is a geometrical investigation of the effect produced by shunting a transformer with a condenser. The author finds that in order to cause a given current to pass in a given inductive circuit we can, by placing a condenser in parallel with it, employ a less electromotive force than would otherwise be necessary, and that a smaller current will flow in the main circuit giving a diminished loss of energy.

The capacity of the condenser giving the best result is $\frac{L}{a^2}$, where L is the self-induction and a the impedance of the inductive branch. W. G. R.

1693. *Lag of Current due to Hysteresis Loss.* **F. Jacobsen.** (Elektrotechn. Zeitschr. 22. p. 529, June 27, 1901.)—If α = angle of lag of current behind p.d. in a transformer with open secondary, B = maximum induction, μ = permeability corresponding to this induction, η = hysteretic constant, then it may be shown that—

$$\sin \alpha = \frac{4\eta B^{1\cdot6}}{H.B},$$

where H = maximum magnetic intensity. Now since $\eta B^{1\cdot6} = \frac{1}{4\pi}A$, where A = area of hysteresis loop, the above formula may be written—

$$\sin \alpha = \frac{A}{\pi H.B}.$$

If now the loop be plotted so that the ordinate a, which represents B, is equal in length to the abscissa which represents H, then πH.B will in the actual diagram be represented by πa^2, *i.e.*, by the area of a circle of radius a. All that is necessary is therefore to find the area of the hysteresis loop, and to divide this by the area of the circle whose radius represents H and B; the quotient gives $\sin \alpha$. A. H.

1694. *Hysteresis of Nickel and Cobalt in Rotating Magnetic Field.* **R. Beattie.** (Phil. Mag. 1. pp. 642–647, June, 1901.)—The method employed by the author is to suspend a thin circular disc of the metal, with its plane horizontal, in a horizontal magnetic field. The field rotates slowly so as to avoid eddy currents and the disc experiences a couple turning it through an angle proportional to the hysteresis loss, the formula being—

$$W = \frac{\pi^2 K}{90V} \cdot \theta,$$

where W is the hysteresis loss per c.c. per cycle, V is the volume of the disc, K is the couple required to produce a twist of one radian, and θ is the deflection in degrees. Curves are plotted with intensity of magnetisation as abscissæ and hysteresis loss as ordinates. The curve for nickel shows that for an intensity of about 340 c.g.s. units the hysteresis loss reaches a maximum value of nearly 10,000 ergs per c.c. per cycle, and rapidly decreases for higher intensities. The maximum hysteresis loss for cobalt, viz., 36,000 ergs per c.c. per cycle, occurs at an intensity of 700 c.g.s. units. In both cases the last part of the curve is approximately a straight line, and if continued as such beyond the highest intensities obtained (375 c.g.s. units for nickel; 980 for cobalt) would lead to the hysteresis loss vanishing at intensities (500 c.g.s. units for Ni; 1,050 for Co) not far removed from the saturation values for the respective metals. W. C. H.

1695. *Magnetic Properties of Alloys of Iron and Aluminium.* **S. W. Richardson** and **L. Lownds.** (Phil. Mag. 1. pp. 601–624, June, 1901. Paper read before the Physical Society of London.)—This paper forms a continuation of a former one by one of the authors on the magnetic properties of an alloy of iron and aluminium [see Abstract No. 657 (1900)] Other alloys are here experimentally examined to determine the hysteresis loss between given limits of the field strength as a function of the temperature. The alloys treated contained 3·64, 5·44, and 9·89 per cent. of aluminium. An abrupt change in the permeability of the last alloy was observed at 652° C. J. B. H.

1696. *Permeability of Nickel Steel in Strong Fields.* **R. Paillot.** (Comptes Rendus, 132. pp. 1180–1181, May 13, 1901.)—The electromagnet used was of the form due to Du Bois, and had conical pole-pieces having a semi-vertical angle of 60° 30′. Steel comprising 24·1 per cent. of nickel and 0·3 of carbon showed at a temperature of 15° C. a value of $\mu = 1{\cdot}020$ in a field of 20,050, rising to $\mu = 1{\cdot}083$ in a field of 30,098. Steel containing 26 to 27·2 per cent. of nickel gave $\mu = 1{\cdot}19$ in a field of 4,000 c.g.s. units, this value remaining practically constant up to H = 30,000. The paper closes with a table of permeabilities for nickel steel with traces of chromium and manganese for fields from 3,000 to 30,000. E. H. B.

1697. *Growth of Magnetism in Iron under Alternating Magnetic Force.* **E. Wilson.** (Roy. Soc., Proc. 68. pp. 218–227, May 23, 1901.)—An iron cylinder 12 inches in diameter has exploring coils at different depths within it, wound through drilled holes crossing one another at right angles, and these coils are connected to d'Arsonval galvanometers. The cylinder was magnetised by a coil carrying a current alternated with a periodic time ranging from 2·5 to 10 minutes. Since the time-scale varies as the square of the linear dimensions of the cylinder, similar events will happen in a 1-mm. wire at 150 periods per second as were observed in the 12-inch core with a periodic time of 10 minutes. In a 1-mm. wire at 50 periods per second the average maximum B over the whole wire is 87 per cent. of that near the surface, when the latter is 2,000 per sq. cm., 80 per cent. when B = 5,000, and 85 per cent. when B = 12,000. With a periodicity of 150 these percentages are respectively 72, 55, and 65. The phase of B in different parts of the core was also examined. W. H. E.

1698. *Circular Magnetisation and Permeability.* **J. Trowbridge** and **E. P. Adams.** (Amer. Journ. Sci. 11. pp. 175–184, March, 1901.)—The permeability of an iron wire to the circular magnetisation produced in it by placing the wire in the circuit of the oscillatory discharge of a condenser is here determined. The period of oscillation is found by the revolving mirror method, the frequencies used ranging from 605 to 3,300 per second. The capacity of the condenser being known from other experiments, the inductance of the circuit is calculated from the expression $T = 2\pi\sqrt{LC}$. Finally, Rayleigh's expression for the inductance of a wire to alternating currents being used, the permeability is found. Its value was 327 for the low frequencies, 711 for the high, and 443 for the intermediate frequency of 1,280 per second. E. H. B.

1699. *Secular Displacement of the Earth's Magnetic Axis.* **A. Nippoldt.** (Phys. Zeitschr. 2. pp. 462–463, May 4, 1901.)—This article is an account of an appendix by **van Bemmelen** to the Observations of the Royal Mag. and Met. Obs. at Batavia, xxii., 1900 [published in English]. The displacement in question was calculated from the secular changes of declination at different places on the earth's surface, as shown on standard charts for different epochs. Since the magnetic meridian planes at different places do not cut in one point in either hemisphere, the end of the axis is defined as the point such that "the sum of the squares of its distances from the projections, on the tangent plane, of all meridians is minimum." The position and direction of motion of the end of the axis [which apparently is supposed to pass through the earth's centre] were computed for six epochs from 1600 to 1885, and a path was plotted. The position for 1885 was found to be about long. 38¼°, lat. 78½°. The values as calculated from different zones were different.

Thus zone 60° N.–30° N. gave $\lambda = 82°$, $\phi = 80°$; zone 20° N.–20° S., $\lambda = 77°$, $\phi = 78°$; zone 30°–60° S., $\lambda° = 48$, $\phi = 74°$. The path of the north end of the magnetic axis was compared with the path of the magnetic North Pole, and the distance between the two found to be about 10·5°, being nearly the same for all the epochs. The altered position of a magnetic meridian during a magnetic storm and the lull following it is regarded as due to a temporary shift of the magnetic axis while the disturbing cause lasts. "If this shift is to be regarded as a circumpolar rotation, the motion is about Nordenskiold's auroral pole, and not about the pole of the earth's rotation." Van Bemmelen's researches lead him to suspect that the position of the axis depends partly on meteorological conditions. A. E.

MEDICAL ELECTRICITY.

1700. *Physiological Action of Pole-discharges of High-tension Induction Currents and of some Invisible Radiations.* **L. Freund.** (Akad. Wiss. Wien, Sitz. Ber. 109. III. pp. 583–654, 1900.)—Direct spark discharges remove the hair from animals; they also retard the development or altogether kill the spores or cultures of *Staphylococcus pyogenes aureus*, typhus bacillus, diphtheria bacillus, anthrax bacillus, tubercle bacillus, and *Achorion Schönleinii*. The action of the direct spark discharge is increased by using an earth connection, by a longer exposure, by a smaller electrode distance, by using a more frequently interrupted primary current, and by using a stronger primary current. The action in question may take place through thin layers of wood, paper, tin-foil, aluminium, or human skin; and it affects micro-organisms suspended in liquids. The physiological action of the negative electrode is stronger than that of the positive, but is effective only at shorter distances. Silent discharges are somewhat less effective than spark discharges, but do not produce pain and are effective within greater ranges. The present investigations have failed to establish any effect of Röntgen rays on the growth of bacteria: Becquerel and phosphorescence rays give the same negative result, with no effect on the normal skin. Direct spark discharges cause hæmorrhages in the tissues of the skin, inflammations, and a pathological condition of the blood-vessels marked by the formation of vacuoles. A. D.

1701. *Electric Nerve Excitation.* **G. Weiss.** (Comptes Rendus, 132. pp. 1143–1145, May 6, 1901.)—In order that an electric excitation of a nerve may become effective, the quantity of electricity must be $a + bt$, where a and b depend on the nerve and the electrode distance. This shows that an inverse phenomenon sets in during discharge which has to be neutralised. The formula agrees with Hoorweg's. H. B.

1702. *Röntgen Rays Produced by Oudin's Resonator.* **R. Demerliac.** (Comptes Rendus, 132. pp. 1586–1587, June 24, 1901.)—In order to obviate the prejudicial effects upon Röntgen-ray patients which is sometimes observed when the vacuum tube is very near and worked by a powerful induction coil, it is here proposed to utilise Oudin's resonator, as it has been observed that tubes worked by alternate currents of high frequency and high potential exhibit effects which are curative instead of injurious. From the experiments made it is concluded that tubes designed specially for this mode of working will give as good results as the ordinary ones now in use give with powerful coils. E. H. B.

REFERENCES.

1703. *Graphic Analysis of Distorted Alternating Current Waves.* **A. S. Langsdorf.** (Phys. Rev. 12. pp. 184–190, March, 1901.)—An ingenious and simple method for determining the coefficients of the Fourier series representing the curve. The process involves only the drawing of a certain number of circles and straight lines. J. E.-M.

1704. *E.M.F. of the Clark Cell.* **H. S. Carhart.** (Electro-Chemist, 1. pp. 37–39, Feb., 1901, and Phys. Rev. 12. pp. 129–136, March, 1901.)—A summary of determinations of the e.m.f. of the Clark cell up to the present time. W. R. C.

1705. *Theory of Natural Electrification.* **M. Frank.** (Elektrochem. Zeitschr. 7. pp. 122–131, Sept.; 155–159, Oct.; 199–206, Dec., 1900; pp. 233–237, Feb.; 266–273, March; and 8. pp. 3–8, April, 1901.)—This series of articles starts with the assumption that each body possesses an appropriate negative charge whose potential depends upon temperature and other conditions of the body. Upon this hypothetical basis a number of phenomena and theories are discussed, among which are: (1) the contact potential of two metals; (2) the general theory of Volta's fundamental experiment; (3) a new thermoelectric phenomenon; (4) the behaviour of the surface layers of metals and their consequences; (5) a galvanic element which has a radio-active substance in place of the electrolyte; (6) the osmotic and thermoelectric theories of the galvanic current generation. E. H. B.

1706. *Wimshurst Machine.* **Bordier.** (Comptes Rendus, 132. pp. 761–763, March 25, 1901.)—Notes are given on the theory of the action of the Wimshurst machine without sectors. J. J. S.

1707. *Leakage of Electricity from Charged Bodies.* **J. C. Beattie.** (Phil. Mag. 1. pp. 442–454, April, 1901. Paper read before the Royal Society of Edinburgh, July, 1900.)—A second paper in continuation of that dealt with in Abstract No. 1376 (1899), and containing many additional results. E. H. B.

1708. *Period of Electric Oscillations by the Rotating Mirror.* **L. Décombe.** (Comptes Rendus, 132. pp. 1037–1040, April 29, 1901.)—A discussion of this method and the possibilities of errors to which it is open, and the means of minimising them. E. H. B.

1709. *Electrical Testing Equipment of a Cable Factory.* **W. Krejsa.** (Zeitschr. Elektrotechn., Wien, 19. pp. 236–238, May 12; 247–251, May 19; and 262–264, May 26, 1901. Paper read before the Elektrotechnishen Verein, March 20, 1901.)—This paper gives an account of apparatus suitable for the various tests usually required. W. H. E.

1710. *Dependence of Dielectric Constant and Permeability on Pressure and Temperature.* **J. Koenigsberger.** (Ann. d. Physik, 5. 1. pp. 113–120, May 4, 1901.)—A mathematical discussion, based upon the conservation of energy and Maxwell's theory, as to the simplest relations between the dielectric and magnetic constants and the pressure and temperature of the media concerned. E. H. B.

1711. *Field of Force of Electric Charges.* **T. des Coudres.** (Archives Neerlandaises, 5. pp. 652–664, 1900.)—The author discusses the various calculations which have been given by Lorentz, Heaviside, J. J. Thomson, and others with regard to the theory of the field of force of electric charges which move with a velocity comparable with that of light, and gives an investigation leading to an equation which is practically the same as that obtained by Heaviside and Lorentz. J. J. S.

1712. *Theory of Electric Conduction in Gases.* **J. Stark.** (Ann. d. Physik, 5 1. pp. 89–112, May 4, 1901.—The substance of this paper has already been published in detached portions [see Abstracts Nos. 2202, 2203 (1900), and 98, 387, 845, and 851 (1901)]. J. B. H.

1713. *Ultra-violet Light and Actino-Electric Phenomena.* **E. Bichat** and **R. Swyngedauw.** (International Physical Congress at Paris, Report, 3. pp. 164–182, 1900.)—A historical survey as to the effect of ultra-violet light in producing (1) discharge of charged conductors, (2) charge of uncharged conductors; as to the effect of polarisation of the light used; as to the mechanism of the transport of electricity under ultra-violet light (leading up to Lenard's discovery that it is due to a spray of kathode rays); as to atmospheric electricity in this connection; and as to the effect of ultra-violet light in lengthening sparking distances. A. D.

1714. *Deformation of Condensers.* **M. Cantone** and **F. Sozzani.** (N. Cimento, 1. pp. 288–289, April, 1901.)—A correction in the values of k in a previous paper [Abstract No. 633 (1901)]. A. D.

1715. *Theories of Coherer Action.* **A. Turpain.** (Écl. Électr. 27. pp. 56–64, April 13, 1901.)—The author gives an account of the various theories which have been suggested to account for coherer action, and gives a classification of coherers. J. E.-M.

1716. *Theory of the Stratified Discharge.* **H. V. Gill.** (Roy. Dublin Soc., Proc. 9. pp. 415–421, June 5, 1901.)—A paper similar to that referred to in Abstract No. 1047 (1898). R. S. W.

1717. *Spark-Induction.* **Klingelfuss.** (Zeitschr. Elektrochem. 7. pp. 642–643; Discussion, pp. 643–644, May 23, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Freiburg.)—Two forms of induction coil are described—in one the iron core is straight and in the other it is a closed ring, the length of spark obtainable being 1 metre. He calculates the voltage of the discharge, which varies with the spark-gap, from known dimension of the apparatus. P. E. S.

1718. *The Electric Arc.* **Bermbach.** (Elektrotechn. Zeitschr. 22. pp. 439–442, May 23, 1901. Paper read before the Elektrotechn. Gesell. at Cologne, Jan. 30, 1901.)—A concise summary of the work which has been done by various investigators on questions connected with the electric arc. W. H. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1719. *Sensitiveness to Light of Fluorescein and its Substituted Derivatives and their Leuco-bases.* **O. Gros.** (Zeitschr. Phys. Chem. 37. pp. 157–192, May 17, 1901.)—The author describes a number of experiments made on fluorescein and several of its derivatives, with the view of elucidating the changes produced in dye-stuffs when subjected to the action of light. To determine the rate of change of the various leuco-bases into the corresponding dyes, the quantity of oxygen used up is measured, two molecules of the leuco-base requiring one molecule of oxygen. The principal results arrived at are: (1) The leuco-bases of the triphenylmethane dyes are extremely sensitive to light. (2) By the entry of a nitro-group into the leuco-base of a fluorescein dye, the velocity with which it changes in the dark into the dye is greatly increased. (3) The bleaching of the triphenylmethane dyes is a process of oxidation. (4) It is very probable that the action of light concerns mainly the ions of the leuco-bases and dyes. (5) The oxidation of the leuco-base is accelerated by the formation of dye, so long as the concentration of the latter does not exceed a certain limit. (6) The sensibility to light of the leuco-bases and dyes is greatly increased by the presence of other dyes. (7) The reaction between mercuric chloride and ammonium oxalate in light is accelerated by the addition of a dye. (8) This catalytic action of the dye is shown in extremely low concentration, and, as the latter increases, the action passes through a maximum. (9) It is in the highest degree probable that the capacity of dyes to act catalytically is brought about by absorption of light. Hence the light-sensitiveness of leuco-bases extends not only to the rays which they themselves absorb, but also to those absorbed by the corresponding dyes. T. H. P.

1720. *Passivity of Iron.* **H. L. Heathcote.** (Zeitschr. Phys. Chem. 37. pp. 368–373, May 31, 1901.)—A number of experiments on the passivity of iron are described, the metal employed consisting of rods of drawn iron of ·5 mm. diameter, and the nitric acid the ordinary "pure" acid of sp. gr. ·408, and containing traces of nitrous acid. The criterion of passivity made use of is that no action visible to the naked eye occurs on dipping the metal into acid of sp. gr. 1·20 at a temperature of 15–17°. In all cases acid of sp. gr. 1·40 or 1·25 is capable of rendering iron passive, but only after some of the metal is dissolved. Electrolytically deposited iron (on copper) is made passive by 1·4 sp. gr. acid, but the passive condition only persists for one or two minutes in 1·2 acid. Yellow, purple, or blue annealed iron is not visibly attacked by acid of sp. gr. 1·3, but on removal is found to be passive. In concentrated nitric acid iron retains its passive state for a long time, but at the same time gradual solution of the metal takes place. Iron made passive by immersion in 1·4 nitric acid is attacked by 1·2 acid after some 10 hours' contact with it. If, however, the acid is kept in motion the speed at which the metal is rendered active is greatly increased; thus, on allowing a stream of 1·2 acid to impinge on a passive iron rod immersed in acid of the same strength, the metal becomes active after one minute. Exactly the opposite is, however, the case when stronger acid (sp. gr. 1·275) is made use of. In other liquids (unmoved) the passive state persists for very different

periods: in concentrated potassium nitrate solution, a few seconds; in double-normal potassium hydroxide, 2–3 minutes; and in saturated solutions of potassium bichromate or ferric alum, several days. Iron can also retain its passive condition when not in contact with any liquid, as is shown by completely removing the acid from a piece of passive iron and placing the latter in a vessel which can be evacuated. In about 50 per cent. of the samples examined in this way the passivity is found to persist after 93 hours, the pressure being 7–8 mm. of mercury. Several of these results are directly contradictory to the views of Hittorf [see Abstract No. 2283 (1900)].

T. H. P.

1721. *Gypsum and Anhydrite.* **J. H. van't Hoff, W. Hinrichsen,** and **F. Weigert.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 25. pp. 570–578, May 9, 1901.)—It having been previously shown that gypsum ($CaSO_4$, $2H_2O$) changes at 107° into the half-hydrate ($CaSO_4$, $\frac{1}{2}H_2O$), the authors describe further experiments to determine the temperature at which further loss of water occurs, with the formation of anhydrite. Contrary to expectation, it is found that the transformation of the half-hydrate into anhydrite takes place at a temperature lower than 107°. In accord with this result is the observation that the tension of water-vapour of a mixture of gypsum and anhydrite is greater than that of gypsum and half-hydrate. From these facts it follows that the half-hydrate can of itself change into gypsum and anhydrite, and is hence unstable or meta-stable. Evidence of this is found in the absence of a layer of half-hydrate intermediate between those of gypsum and anhydrite in natural salt deposits. Further confirmation of this is obtained by experiment.

T. H. P.

1722. *Flame Spectra of the Basic Bessemer and Open-hearth Processes.* **W. N. Hartley** and **H. Ramage.** (Roy. Soc., Phil. Trans. 196. pp. 479–506, June 5, 1901; and Abstract in Roy. Soc., Proc. 68. pp. 93–97, March 25, 1901.)—Photographs of the flame, sparks, and fume at the various stages of the "blow" were taken, as well as of the spectra, and differed entirely from the results in the "acid" Bessemer process as recorded in former papers. The continuous spectrum was much stronger, and many new lines and bands were observed. Rb, Cs, Ca, Cu, Ag, and Ga were identified, besides K, Na, Li, Fe and Mn. Very careful analyses of the materials and products were also made and gallium oxide was separated from the iron. No information was furnished by the spectroscope as to phosphorus, probably because that element is fixed by Ca and Fe and not volatilised, but an insight was obtained into the chemistry of the process, and as to the wide distribution of rarer elements and the variations of spectra with temperature. The open-hearth and cupola flames did not show the lines, because the atmosphere is an oxidising one. The basic Bessemer "blow" is vividly described, and the spectra tabulated. It is shown that Rb and Cs accompany the lime, while Ga, Cu, Ag, and some Rb enter with the iron. A new line of potassium with variable intensity was established, λ 4642–3. V and Ti are removed with the slag along with the phosphorus, and do not appear in the spectrum. By analysis Pb, Cr, Ni and traces of Co were found in the basic steel, and Sr in the lime, but their lines were not visible in the converter flame. Certain variations of the spectra caused by temperature are described.

S. P.

1723. *Density of Alloys.* **E. van Aubel.** (Comptes Rendus, 132. pp. 1266–1267, May 28, 1901.)—The alloy AlSb melts at 1078°–1080°, while Al melts a

60° and Sb at 638°. It is found that its sp. gr. is 4·2176 instead of 5·2246 assuming no expansion (Al 18·87 at sp. gr. 2·67 and Sb 81·13 at sp. gr. 6·72): there is therefore a considerable increase in volume, contrary to Matthiessen's rule. A. D.

1724. *Results of Chilling Copper-Tin Alloys.* **C. T. Heycock** and **F. H. Neville.** (Roy. Soc., Proc. 68. pp. 171–178, May 23, 1901.)—Attempts to elucidate the nature and composition of copper-tin alloys were made by the microscopical examination of their structure. The paper is illustrated by photographs of the structures observed in the slowly cooled as well as in the chilled or suddenly cooled alloys. It is considered "that the patterns of slowly cooled copper-tin alloys are, at all events until they have been confirmed by the examination of chilled portions, entirely misleading as to the separations that occurred during solidfication. Even the evidence for the existence of the compound Cu_3Sn will have to be revised." N. L.

1725. *Thermo-chemistry of Alloys of Copper and Zinc.* **T. J. Baker.** (Roy. Soc., Phil. Trans. 196. pp. 529–546, June 13, 1901. Abstract in Roy. Soc., Proc. 68. pp. 9–10, March 5, 1901.)—A number of experiments on the same lines as those previously described [Abstract No. 1112 (1900)] were made, the heat of formation of the different alloys being calculated from the heats of solution of the alloy and of the two constituents. The solvents employed were chlorine water, ammonium ferric chloride solution, and ammonium cupric chloride solution. The production of an alloy of copper and zinc is always attended by evolution of heat, the maximum evolution of 52·5 calories per gramme corresponding with the alloy $CuZn_2$; the heat of formation of this compound would therefore be 10,134 calories per gramme-molecule. There is also evidence of the existence of an alloy CuZn, having a heat of formation of about 45 calories per gramme. These results are in agreement with Kelvin's calculation of the molecular dimensions of copper and zinc as lying between 10^{-8} and 10^{-9} cm. It is also pointed out that a complete theory of the electro-deposition of brass must take into account the energy liberated in the combination of copper with zinc. N. L.

1726. *Studies on Inversion.* **E. Cohen.** (Zeitschr. Phys. Chem. 37. pp. 69–83, May 3, 1901. Paper read before the Akad. Wiss. zu Amsterdam, May 25, 1900.)—It has been shown by previous observers that the hydrolysis of ethyl acetate by alkalis is retarded by various substances, such as glycerol and sugar, usually classed as non-electrolytes. In the present paper are described series of experiments on the influence of sucrose, invert sugar, dextrose, lævulose, and mannitol on the velocity of hydrolysis of N/40 ethyl acetate by N/40 sodium hydroxide at 25°. The results, which are given in tables, and also in the form of curves, show that mannitol exerts but little influence on the reaction, whereas the sugars exercise a comparatively strong retarding influence, and may therefore be regarded as weak acids. N. L.

1727. *Velocity of Chemical Reactions.* **W. Duane.** (Amer. Journ. Sci. 11. pp. 349–356, May, 1901.)—Two methods are described for measuring the rate of change, the first, applicable to transparent bodies, depending on alteration in the index of refraction, the instance given being the inversion of cane sugar. By the apparatus illustrated it is proved that "the distance of the image at any time from its final position after the reaction has been completed is very approximately proportional to the amount of cane sugar left in

the solution at the time." The image of a slit is photographed successively on the same plate, and the distances measured by a micrometer scale. It appears that the velocity of the reaction is greater at the beginning and less at the end than would be expected from Gouldberg and Waage's law that the rate at which the cane sugar disappears should be proportional to the amount left in solution.

The second method is based upon the change in the volume of the chemical system during the reaction. The liquids are contained in a spiral glass coil with a ground stopper and cup at one end, and at the other a capillary tube with a mercury index, the whole being enclosed in a bath regulated to a constant temperature by an electrical thermostat devised by the author, sensitive to $\frac{1}{1000}$ degree. In the apparatus described, the spiral tube contained 100 c.c. of solution, the capillary was 36 cm. long, and 1 sq. mm. in section, and the temperature was 25·872° C. The velocity of change was again less rapid at the end. A third method depending on the change in the index of refraction as measured by the motion of inteference bands is under investigation. S. R.

1728. *Order of Crystallisation of Minerals in Igneous Rocks.* **J. A. Cunningham.** (Roy. Dublin Soc., Proc. 9. pp. 383–414, May 7, 1901.)—The order of crystallisation of minerals in igneous rocks can generally be expressed by Rosenbusch's law that the most basic rocks crystallise first, and, in particular, quartz is always the last to crystallise in deep-seated plutonic rocks. This order is, however, entirely different from the order of the melting-points and Joly has therefore suggested that the order of crystallisation is dependent on the temperature at which the minerals become viscous or ductile. A considerable amount of evidence is available to show that whilst a fibre of amorphous silica becomes ductile at 800°, quartz itself does not melt until above 1,400°, and as quartz is denser than amorphous silica this melting-point would be raised by increasing the pressure. Bunsen, in 1850, showed that in the case of paraffin wax and spermaceti the melting-point of the more fusible paraffin rises more rapidly than that of spermaceti on increasing the pressure, so that above 95 atmospheres the order of fusibility is reversed; if the melting-points of augite or orthoclase rise more rapidly with increase of pressure than the melting-point of quartz, they should separate the first under great pressures, but the last under low pressures, and evidence is given to show that this change in the order of crystallisation actually occurs in certain granite masses at different depths.

The paper gives an account of the methods by which the influence of pressure on the melting-points of minerals may be determined, but the data are at present very scanty. T. M. L.

1729. *Theory of Colloidal Solution.* **F. G. Donnan.** (Phil. Mag. 1 pp. 647–652, June, 1901. Paper read before the Physical Society of London.) —The author shows that the phenomena of colloidal solutions can be explained by means of Laplace's theory of intermolecular attractive forces. The pseudo-solution of colloidal matter is regarded as a process of molar or mechanical disintegration due to the non-existence of statical equilibrium in the thin surface-layers of the solid when the latter is in contact with certain liquid media. Any small volume-element in the bounding interface of a solid immersed in a liquid is acted on by two forces, one l due to the attraction of the solid, and the other r to that of the liquid. For crystalline solids l is greater than r, while for colloidal matter in contact with certain liquids it is

assumed that r is greater than l. The solid will therefore begin to disintegrate into the liquid; and to account for the stoppage of the disintegration process before the molecular limit is arrived at, that is, before true solution sets in, the author further assumes that the molecular adhesion between the liquid and solid is greater than the molecular cohesion of the colloid and that for the latter, the intermolecular attractive forces fall off more rapidly with increasing distance than for the former. Hence there exists a critical thickness of the colloidal substance such that the forces l and r just balance and when this state of division is reached the process of disintegration ceases, the result being a two-phase system consisting of the colloidal medium distributed in a state of extremely fine division throughout the liquid.

T. H. P.

1730. *Solubility of Mixtures.* **V. Rothmund** and **N. T. Wilsmore.** (Zeitschr. Elektrochem. 7. pp. 676–677; Discussion, pp. 677–678, May 30, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—By extending Dalton's law to dilute solutions it should follow that the solubility of a substance would not be influenced by the addition of small quantities of a third substance. This is not the case where electrolytes are concerned, and the solubility of a non-electrolyte in water is always diminished by the presence of an electrolyte; for example, the solubility of a non-electrolyte in a normal solution of a sulphate is 40 per cent. less than its solubility in water. From this it must follow that the solubility of the electrolyte in water is diminished by the presence of the non-electrolyte, and the equation—

$$l_1 \log_e \frac{L_1}{l_1} = il_2 \log_e \frac{L_2}{l_2}$$

is deduced, where L_1 and l_1 are the solubilities of the non-electrolyte in water and in a saturated solution of the electrolyte, L_2 and l_2 are the solubilities of the electrolyte in water and in a saturated solution of the non-electrolyte, and i is van't Hoff's factor. To test this formula an experiment was made with water, phenol, and potassium sulphate where—

$$L_1 = 0{\cdot}893, \quad l_1 = 0{\cdot}493, \quad i = 2{\cdot}33,$$
$$L_2 = 0{\cdot}671, \quad l_2 = 0{\cdot}534:$$

these figures give—

$$l_1 \log_{10} \frac{L_1}{l_1} = 0{\cdot}127, \quad il_2 \log_{10} = \frac{L_2}{l_2} 0{\cdot}121,$$

and afford a satisfactory confirmation of the equation given above.

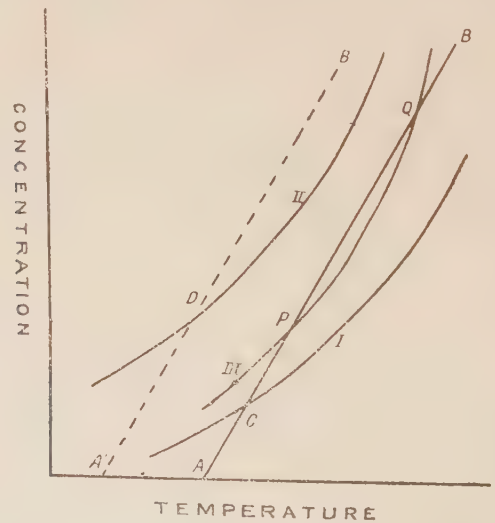
In the discussion **Abegg** urged that combination of the solute with the solvent is probably of very common occurrence, and that, for instance, in an iodine solution the concentration of the *free* iodine is probably only that of saturated iodine vapour; the addition of a third substance would decrease the active mass of the solvent and so diminish the amount of combined iodine and reduce the solubility.

T. M. L.

1731. *Solubility of Gases in Organic Solvents.* **G. Just.** (Zeitschr. Phys. Chem. 37. pp. 323–367, May 31, 1901.)—Results are given of the measurement of the solubilities of carbon dioxide in 44 organic liquids and of carbon monoxide, nitrogen, and hydrogen, in 17 liquids, besides a few mixtures of such liquids, the modified form of Ostwald's apparatus devised by Timofejew and Steiner being employed. The numbers obtained for carbon dioxide

show that for the series of the monohydric alcohols the solubility of the gas decreases as the molecular weight of the alcohol increases, and the same relation holds for the fatty acids, the aromatic hydrocarbons, and the alkyl acetates. Similar relations are not met with in the cases of the other gases examined. The solubility values at 20° and 25° show that, between these temperatures the solubilities of nitrogen, hydrogen, and carbon monoxide in most liquids increase as the temperature rises, whilst the opposite holds in the case of carbon dioxide. From a table giving for the different gases at 25° the liquids arranged in the order of their dissolving power, it is seen that the series for nitrogen and carbon monoxide are almost identical. Further, while for other pairs of gases the ratios of the solubilities in one and the same liquid vary considerably for the different solvents, the solubility of carbon monoxide is in all cases about 1·44 times (at 25°) that of nitrogen in the same liquid. Whether these relations depend in any way on the equal molecular weights of the two gases concerned is unknown. Numerous tables of experimental numbers accompany the paper. T. H. P.

1732. *Separation of Salts by Evaporation of Dilute Solutions.* **F. W. Skirrow** and **H. T. Calvert.** (Zeitschr. Phys. Chem. 37. pp. 217–219, May 17, 1901.)—If the line AB represents the boiling-points of solutions of different concentrations the solubility curve will usually intersect it at a single point; and on evaporating a dilute solution, solid will separate at a temperature and concentration represented by the point C (curve I). In other



cases the solubility curve (II) does not intersect the boiling-point curve, and the temperature can be raised to the melting-point of the salt without any separation of solid taking place; this case is illustrated by aqueous solutions of sodium and potassium hydroxides; if the evaporation takes place under reduced pressure the line AB will be moved to a parallel position A'B' nearer the origin, and solid may then separate at a temperature and concentration represented by the point D. In certain cases the solubility curve (III) may intersect the boiling-point curve at two points, P and Q, and solid will then separate only at intermediate temperatures. T. M. L.

1733. *Experimental Verification of a Law of Chemical Dynamics.* **H. Pélabon** (Comptes Rendus, 132. pp. 1411–1413, June 10, 1901.)—The law $p_1 p_2 / p_3 p_4 = f(t)$ is here tested for the reciprocal reaction given by—

$$HgS + H_2 = H_2S + Hg,$$

by experimenting (1) with H_2 acting on HgS alone, (2) with H_2 acting on HgS with Hg present in excess, (3) with H_2S acting on Hg in excess. In (1) the calculated value of the ratio of the partial pressure of H_2S to the whole pressure is always slightly larger than that obtained by experiment; in (2) calculation and experiment are in good agreement; in (3) the agreement is less good, doubtless owing to partial decomposition of H_2S during the sealing of the tubes. [See also Abstract No. 1121 (1900).] R. E. B.

1734. *Fundamental Equations of Multiple Points.* **J. E. Trevor.** (Journ. Phys. Chem. 5. pp. 259–260, April, 1901.)—A deduction is given of the equations due to Saurel [See Abstract No. 1354 (1901)], and it is pointed out that the fundamental equation may also be written in the form—

$$\bar{W}_{12}\frac{dp_{12}}{d\theta} + \bar{W}_{23}\frac{dp_{23}}{d\theta} + \ldots + \bar{W}_{(n+2)1}\frac{dp_{(n+2)1}}{d\theta} = 0,$$

$\bar{W}_{mn}$ being the work absorbed in the transfer of unit mass from the mth to the nth phase.

The author also deduces, in the case of a one-component system, the equations—

$$\bar{Q}_{12}\frac{d\mu_{12}}{dp} + \bar{Q}_{23}\frac{d\mu_{23}}{dp} + \bar{Q}_{31}\frac{d\mu_{31}}{dp} = 0,$$

$$\bar{W}_{12}\frac{d\mu_{12}}{d\theta} + \bar{W}_{23}\frac{d\mu_{23}}{d\theta} + \bar{W}_{31}\frac{d\mu_{31}}{d\theta} = 0,$$

μ being the chemical potential: these equations admit of extension to n-component systems. W. E. T.

1735. *Thermodynamics of Saturated Solutions.* **N. Schiller.** (Ann. d. Physik, 5. 2. pp. 326–348, May 29, 1901.)—This is a mathematical paper in which the author treats of the behaviour of saturated solutions under varying external conditions; for example, he inquires whether these variations cause some of the undissolved substance to dissolve or some of the dissolved substance to precipitate. Among other things he proves that, in the case of a single substance in solution, external pressure in general promotes solution and the osmotic pressure in a saturated solution is in general increased by compression. In cases where two fluids dissolve into one another and form two saturated solutions the effect of the external pressure in general depends on the relative quantities of the two fluids. The osmotic pressures of both solutions, certain particular cases being excepted, are increased by increase of external pressure. W. E. T.

1736. *Salt Formation between Cane Sugar and Potassium Hydroxide as shown by Conductivity.* **C. J. Martin** and **O. Masson.** (Chem. Soc., Journ. 79. and 80. pp. 707–714, June, 1901.)—It is found that the conductivities of solutions of KCl and HCl are decreased by the addition of cane sugar. This effect, which is due to the increase of viscosity and has been investigated by Arrhenius, is found to follow very approximately a linear law, $l = l_0(1 - ax)$,

where l = conductivity of solution, l_0 = conductivity of solution containing no sugar, x = grm.-mols. sugar per litre and α = a constant.

In the case of KOH, however, the results are quite different, showing with increase of sugar concentration a much more rapid rate of falling off in conductivity at first. As the solution gets stronger with respect to sugar the rate of decrease of conductivity diminishes, the result being a markedly curved line when l is plotted against x. These results point to the formation of "sucrate" ions in the solutions, and show that in the presence of a strong base cane sugar can act like a weak acid. [Compare the results of Kullgren, Bihang t. Vet. Akad. Stockholm 24, II., No. 8, 1898.] F. G. D.

1737. *Vapour-Pressures of Isomorphous Mixtures of Salt-Hydrates.* **R. Hollmann.** (Zeitschr. Phys. Chem. 37. pp. 193–213, May 17, 1901.)—It is found that isomorphous mixtures possess true maximum vapour-pressures independent of the amount of water of crystallisation present, between certain limits, and that the vapour-pressure of a salt-hydrate is always lowered by isomorphous admixture, provided the latter be small.

On varying the proportions of the two salts present it is found that the vapour-pressure curves exhibit cusps, which must be regarded as the points of intersection of different curves. These cusps occur always at points corresponding to simple ratios of the component salts, and in fact indicate the existence of corresponding *double-salts* formed by the isomorphous constituents. The following double-salts appear on these grounds to exist:—

2 mol. iron alum + 1 mol. ordinary alum.
2 mol. chrome alum + 1 mol. ordinary alum.
2 mol. magnesium sulphate + 1 mol. zinc sulphate.
1 mol. „ „ + 1 mol. „ „

F. G. D.

1738. *Influence of Sodium Sulphate on the Vapour-Pressure of Aqueous Ammonia.* **E. P. Perman.** (Chem. Soc., Journ. 79. and 80. pp. 725–729, June, 1901.)—The author gives the values of the vapour pressure of ammonia solutions containing sodium sulphate for temperatures varying from 26° to 47°. Comparison with the numbers for pure ammonia solutions shows that the vapour pressure is much increased by the presence of sodium sulphate, and is even higher than it would be on the supposition that the hydrate $Na_2SO_4.10H_2O$ is formed, the concentration of the ammonia being thus increased. This effect is probably due to a displacement, more physical than chemical, of the ammonia by the salt. The vapour-pressure curves of ammonia solution containing dissolved sodium sulphate are continuous, indicating that no sudden change occurs in the state of hydration of the salt. This observation agrees with the now generally-accepted view that the break in the solubility curve of sodium sulphate at 33° is due to a change in the solid with which the solution is in contact. T. H. P.

1739. *Vapour-Pressure of Aqueous Ammonia Solution.* Part I. **E. P. Perman.** (Chem. Soc., Journ. 79. and 80. pp. 718–725, June, 1901.)—Results are given of measurements by a statical method of the vapour-pressures of aqueous ammonia solutions of concentrations varying from 0 to 35 per cent. for temperatures of 0° to 60°. No simple relation can be observed between the vapour-pressure and the concentration, or between the vapour-pressure and temperature of the solution. Curves and tables accompany the paper.

T. H. P.

1740. *Cryoscopic Experiments with the Bromides of Arsenic and Antimony.* **G. Garelli** and **V. Bassani**. (Accad. Lincei, Atti, 10. pp. 255–262, April 4, 1901.)—The authors give the results of cryoscopic measurements of benzene, bromoform, iodine, arsenic tri-iodide and trichloride, stannic iodide, antimony chloride, and bromide in arsenic bromide solution and of diphenyl, diphenyl-methane, bromoform, antimony chloride, arsenic tri-iodide, and tribromide in antimony bromide. The numbers obtained lead to the following conclusions. The mean molecular freezing-point depression for arsenic bromide is 194·2, which agrees well with the value given by Raoult's empirical rule, namely, 195·3. Solutions of antimony chloride in arsenic bromide give freezing-point depressions much less than the theoretical, a fact ascribed by the authors to the formation of solid solutions. Tolloczko [see Abstract No. 383 (1900)] found that solutions of arsenic bromide in antimony chloride give small depressions of the freezing point, and he supposed that either dissociation or a chemical action such as $AsBr_3 + SbCl_3 = AsBr_2Cl + SbCl_2Br$ takes place. This explanation is untenable in the light of the authors' observations. The small depressions obtained by Tolloczko for solutions of arsenic bromide in antimony choride are probably also due to the analogy in constitution existing between the solvent and solute. Anomalous values are also obtained for mixtures of the bromides of arsenic and antimony, and are evidently due to the formation of isomorphous mixtures. Tolloczko (*loc. cit.*) corrects the number, 280, previously given by Garelli for the molecular freezing-point depression of stannic bromide, giving the value 306. The authors point out that both from the results of Tolloczko and those of Garelli the latter number is too high, whilst 280 agrees well with the value given by Raoult's rule, the melting point and latent heat of fusion leading to the number 260. T. H. P.

1741. *Conductivity of Solutions of Salts in Liquid Sulphur Dioxide up to and above the Critical Temperature.* **A. Hagenbach**. (Ann. d. Physik, 5. 2. pp. 276–312, May 20, 1901.)—The conductivity of solutions of a number of iodides and bromides when dissolved in sulphur dioxide was determined at temperatures up to and above the critical point (156° C.). When the critical point was reached it was noticed that with coloured solutions the vapour began to be coloured just before the disappearance of the meniscus, but that after the meniscus had disappeared the vapour in the lower part of the tube was much more deeply coloured than that in the upper part of the tube; similarly the lower layer of vapour had a much higher conductivity than the upper layer. This is due to the slowness with which the solute diffuses; the inequality disappears gradually if the temperature is kept constant, or immediately if the tube is shaken.

Electrolytic conductivity, accompanied by polarisation, was observed at temperatures a few degrees *below* the critical point both in the saturated and the unsaturated vapour, and also in the vapour *above* the critical temperature. The temperature-coefficients of the liquid solutions were negative, and amounted to about 2 per cent. per 1° for temperatures between 100° and 140°; potassium iodide, however, showed a positive temperature-coefficient between 18° and 87°, the conductivity rising to a maximum at the latter temperature. Just below the critical temperature a large decrease of conductivity occurs, the temperature-coefficient increasing in magnitude to about —50 per cent. Above the critical temperature the temperature-coefficient of the vapour is again small. The conductivity curves are therefore continuous from the liquid to the gaseous state, but show a marked inflexion just below the critical temperature.

Corresponding experiments with water as a solvent were impracticable owing to the dissolution of the glass, but a maximum of conductivity was once observed at 310° in a solution of potassium chloride containing a large amount of dissolved glass. [See also Abstract No. 2456 (1900)]. T. M. L.

1742. *Calculation of the Ionisation of Strong Electrolytes.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 37. pp. 315–322, May 31, 1901.) –The values of determined by the freezing-point measurements of Loomis and Hausrath for KCl, NaCl, and HCl are compared with the values calculated from the formula $i = 1 + \alpha$, where α is ascertained from the conductivity. It is maintained that the agreement is as good as could be expected in consideration of the experimental errors. According to the author [Abstract No. 908 (1901)] Jahn's measurements appear to indicate a constant error of about 1 per cent. The author points out, however, that he does not identify i with $1 + (n-1)\alpha$ in *all* cases, as that would be tantamount to assuming the validity of the simple gas laws in all cases. The formula given by the author for the e.m.f. of a concentration cell does *not* assume the gas-laws, and is exact. Nevertheless in many cases of dilute solutions of binary electrolytes the equation $i = 1 + \alpha$ holds, as shown above. F. G. D.

1743. *Free Formation-energy of Water, and a New Electrode Sensitive to Light.* **E. Bose.** (Zeitschr. Elektrochem. 7. pp. 672–675, May 30, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Freiburg.)—Various observations recently made indicate that the value of 1·08 volt for the e.m.f. corresponding to the reversible formation of water from hydrogen and oxygen is certainly too small. The author gives various values founded on the experiments of different observers. As a provisional value for this e.m.f. at 76 cm. pressure and 25° C. temp. the number $E = 1{\cdot}1392 \pm 0{\cdot}0150$ volt is given. In considering the effect of the electrode metals, the author experimented with an element with gold electrodes of a special construction. He found this cell sensitive to light and various diagrams are given showing the changes of e.m.f. when the electrode was exposed to light of different colour and when the light was not allowed to reach it. J. J. S.

1744. *Acetylene as a Depolarising Agent.* **A. Coehn.** (Zeitschr. Elektrochem. 7. pp. 681–684, June 6, 1901. Paper read before the Deutsch. Elektrochem. Gesellschaft at Freiburg, April 19, 1901.)—Using acetylene at the anode in an alkaline solution (KOH) formic acid is produced in quantitative proportions, and the discharge potential of the anion is lowered by 0·48 volt. The current-efficiency of the cell worked in this way lies between 95·9 and 98·7 per cent., and corresponds to the equation—

$$C_2H_2 + 6OH = 2HCOOH + 2H_2O.$$

Substituting normal sulphuric acid as electrolyte, the lowering of the discharge potential of the anion only equalled 0·19 volt, and chemical tests proved that acetic acid was formed with the corresponding aldehyde as an intermediate product.

The formation of acetic acid at the anode was proved to be quantitative.

Further experiments with the halogen acids as electrolytes yielded inconclusive results, but a slight lowering of the discharge potential of the anion was noted. The investigation is being continued by the author.

J. B. C.

1745. *Periodic Phenomena in Electrolysis.* **K. Kœlichen.** (Zeitschr. Elektrochem. 7. pp. 629-633; Discussion, pp. 633-635, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—Periodic phenomena occur in the electrolysis of sodium and ammonium sulphides, similar to those observed by Ostwald in the dissolution of metallic chromium [Abstract No. 163 (1901)]. The p.d. at the kathode remains steady whilst that at the anode varies widely; the polarisation at each electrode remains steady and the fluctuations in the current are therefore due to a variable anode resistance. This variation of resistance has been traced to the deposition of sulphur and subsequent dissolution in the sulphide. The period is much shorter than that observed by Ostwald. The variations of current were recorded by means of a hot wire connected to the pen of a recording apparatus. The phenomenon is most marked in strong solutions of sodium sulphide with a current-density of 10-20 amperes per sq. dm. and rough platinum electrodes. The presence of polysulphides in the solution makes the phenomenon less pronounced, but this effect can be partially overcome by increasing the concentration and current-density. For each concentration there is a minimum and a maximum temperature at which the variations can be observed, the necessary current-density being small at the minimum temperature and large at the maximum. Similar periodic phenomena occur in the electrolysis of potassium iodide, and two other cases are mentioned in the discussion. T. M. L.

1746. *Electrolytic Phenomena at the Function between two Solvents.* **E. H. Riesenfeld.** (Zeitschr. Elektrochem. 7. pp. 645-647, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—An investigation of the concentration-changes produced by the current at the interface between solutions of the same electrolyte in two partially miscible solvents. It is shown theoretically that there will be an increase of concentration at one junction, and an equal decrease at the other (supposing the two solutions to be contained in a U-tube), and that this variation of concentration will be proportional to the difference between the migration-constants of the kation (or anion) in the two solvents. Experiments are described with KI_3 distributed between water and phenol. If Ficks' law of diffusion be employed, and a linear distribution-law between the two solvents assumed, it is found possible to obtain expression free from the integral sign, giving the state of the solution at any given point and any given time. Thus if m_1 and m_2 denote the fluxes *from* the interface *into* the solvents 1 and 2 respectively, it appears that m_1 and m_2 are independent of the time, and that—

$$\frac{m_1}{m_2} = k \sqrt{\frac{D_1}{D_2}}$$

where the D's denote diffusion-coefficients, and k is the distribution-coefficient. It is shown how the migration-constants for the KI in the phenol solution can be determined from analyses of the aqueous kathodic solution alone; in this way the mean value (0·81) is found for the migration constant of the kation. F. G. D.

1747. *Electrolytic Reduction of Ketones.* **K. Elbs.** (Zeitschr. Elektrochem. 7. p. 644, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—As a general rule the reduction of ketones by sodium hydrate and zinc dust yields the corresponding alcohols, while reductions by zinc dust and glacial acetic acid yield the pinacones. Complex ketones,

containing aromatic radicle groups, are not, however, in all cases reduced by chemical means, and, therefore, experiments were made to test the effects of electrolytic action. The best results were obtained when using slightly acid or alkaline solutions with lead electrodes. Under such conditions all ketone derivatives could be reduced by electrolysis. This method of reduction has, in fact, been found to work so well that the firm of E. Merck has patented its application to the production of isopropylalcohol and pinacone from acetone. A 90 per cent. yield has been obtained for this reduction in the laboratory trials of the process. J. B. C. K.

1748. *Electrolytic Separation of Cobalt and Nickel.* **D. Balachowsky.** (Comptes Rendus, 132. pp. 1492–1495, June 17, 1901.)—An acetic acid solution of the two metals is employed, with the addition, for each 0·3 gramme of metal, of 3 grammes of ammonium sulphocyanide, 1 gramme of urea, and 1 or 2 c.c. of ammonia to neutralise the excess of acetic acid. The liquid should measure about 100 c.c., and is electrolysed at 70–80° in a Classen capsule, using an e.m.f. not exceeding 1 volt and a current density at least $ND_{100} = 0{\cdot}8$ ampere ; 1½ hours is required for the electrolysis. Under these conditions the nickel is deposited on the kathode in the form of sulphide, which is subsequently dissolved in nitric acid, and the metal is deposited by Classen's usual process. N. L.

1749. *Electrolytic Chromium.* **B. Neumann.** (Zeitschr. Elektrochem. 7. pp. 656–658 ; Discussion, pp. 658–661, May 30, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—After referring to Bunsen's experiments in 1850 for the deposition of chromium from its solutions, the author gives his own experience on the subject. His investigations were made by means of simple solutions of chromium salts contained in the kathodic compartment, the anode compartment containing mineral acids or solutions of a salt. The kathode consisted generally of carbon ; however, such metals as platinum, brass, lead, &c., may be employed, and the anode may be, according to the solutions, of lead, platinum, or carbon. Vigorous agitation of the solutions is essential, as otherwise the solutions round the kathode will rapidly become exhausted, owing to the great current-densities which must be employed, and only oxides of chromium will be the result.

Tables referring to concentration, temperature, and current-densities employed are given ; yields ranging from 5·4 per cent. to 89·5 per cent. of the theoretical were obtained. Sulphate solutions were also tried and yielded up to 84·6 per cent., with 65–85 grs. of chromium per litre. Acetate solutions gave poor yields and bad deposits. If properly prepared the deposits have a tendency to peel off in thin layers, somewhat like nickel. Thicker deposits of several millimetres may, however, be made, and are very pure, only containing 0·1 to 0·2 per cent. of iron. Both modifications, *i.e.* the active and passive, were obtained, as in Goldschmidt's method. A discussion followed the paper. O. J. S.

1750. *Electrolytic Preparation of Benzidine.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 597–603, May 9, 1901.)—Under certain conditions azoxybenzene may be reduced to benzidine with a yield of 64 to 70 per cent. Azoxybenzene (2 grammes) is suspended in 25·75 per cent. hydrochloric acid (70 c.c.), containing stannous chloride (1–1·5 grammes) in solution ; the liquid is placed in a porous pot standing in hydrochloric acid. The kathode is formed of pure nickel gauze, and it is also used as a stirrer in order to keep the

azoxybenzene in suspension. The kathodic current-density may vary from 0·008 to 0·05 ampere per sq. cm., and the temperature from 60° to 90°. Little or no benzidine was obtained when other salts were added to the solution, or other metals used as kathodes. O. J. S.

1751. *Electrolytic Bleaching.* **W. McA. Johnson.** (Elect. World and Engineer, 37. p. 765, May 11, 1901.)—A brief illustrated article, giving details of experiments carried out in the Laboratory of Trinity College, Hartford, Conn. The fabric to be bleached was saturated with a solution of sodium chloride containing free hydrochloric acid, and placed between two carbon electrodes carrying a weak current at an e.m.f. of 2 volts. The bleaching effect at the anode is due to the nascent oxygen, produced by the secondary chemical reaction between the liberated chlorine and the water. The best results are obtained with a very small current-intensity, and an e.m.f. below 1·67 volts, as that is the "Zersetzungspunkt" of the OH ions. J. B. C. K.

1752. *Bell Type of Alkali Cell.* **G. Adolph.** (Zeitschr. Elektrochem. 7. pp. 581–589, May 2, 1901.)—The principle of this type of cell is that gravity effects the separation of the alkali hydrate-solution formed at the kathode. The anode compartment is simply the suspended bell jar, and no diaphragm is used to separate the anode and kathode compartments of the cell. The best results were obtained when using platinum as anode material, the current-efficiency under favourable conditions rising to 97·68 per cent., but eminently satisfactory efficiencies were obtained with carbon anodes, 92·97 per cent. and 92·68 per cent. being recorded in two separate experiments. The possibility of working continuously with this form of alkali cell was shown by a test lasting seven days, during the last five of which fresh salt solution was continuously fed into the cell. The current-efficiency obtained during this trial was 82·1 per cent.

The author concludes his paper by stating his belief that this type of cell is worthy of attention by those interested in the technical aspects of the subject. J. B. C. K.

1753. *Electric Production of Ferro-Silicon.* **G. Gin.** (Ind. Élect. 10. pp. 173–178, April 25, 1901 ; also Écl. Électr. 27. pp. 177–185, May 4, 1901.)—The first portion of this paper deals with the part that silicon plays in the Bessemer process. The following is the order of oxidation in this process : Silicon, manganese, iron, carbon, and finally phosphorus, the latter being fixed by means of basic materials such as lime, &c. Thermo-chemical data are then considered, and the importance of the heat supplied by means of the combustion of the silicon explained, 7,830 calories being thus disengaged. One per cent. of silicon in cast iron, low in carbon, imparts to it the maximum tensile strength. Certain classes of open hearth and Bessemer steels are also improved by the presence of silicon if properly balanced with the percentage of carbon present. The various silicides of iron, five in number (Fe_3Si, Fe_2Si, Fe_3Si_2, Fe_2Si_2, and $FeSi_2$) with 14·28 per cent. to 50 per cent. of silicon are then fully described. The industrial production of ferro-silicon at Meran is explained. Charges similar in composition to those in blast furnaces were first employed, the only difference being the reduction of coke on account of the heat supplied by the current. The mixture consisted of 1,000 kilos iron oxide, 410 kilos sand, and 398 kilos coke, 70 watts being employed per sq. metre, the operation lasting fifteen hours with a yield of 776 kilogrammes, which equals 1,240 kilogrammes for twenty-four hours per furnace, or 80 per

cent., calculated on the silicon employed, the final product containing 21· per cent. Si. Cost of production per ton, 200 francs. Ferro-silicons of higher percentage were also produced, and up to 83 per cent. yield obtained. The sale price in Austria is 200 kroners for a 10 per cent. alloy, the price being correspondingly higher with an increase of silicon. In France, ferro-silicon of 10 per cent. is worth about 180 francs, and a 25 per cent. alloy 300 francs. This is an increase of 8 francs for each per cent. between 10 and 25 per cent. Above 25 per cent. each unit costs 10–12 francs per ton. At another works, trials with inferior silicious ores were made containing manganese, the latter being nearly entirely volatilised. The results in this case were very satisfactory, 75 per cent. of the electrical energy employed being accounted for. The most satisfactory results were, however, obtained by employing practically worthless acid and Siemens-Martin slag as raw material, yielding ferro-silicon and silico-spiegels containing about 30 per cent. silicon. The loss of silicon in this case was somewhat higher owing to the high temperatures employed. Power consumed per ton equalled 5,380 kw.-hours. A saving of 12 per cent. of power was thus effected, and 120 kilos less coke employed, thus saving 14 francs per ton without counting the further saving on account of valueless raw material. Reference is also made to Scheid's method of the production of metallic silicon, and the author states that he has obtained much better results by using a mixture of silicon, carbon, and fluorspar. The whole paper is carefully worked out from thermo-chemical data. O. J. S

1754. *Reduction of Arsenic Ores in the Electric Furnace.* **C. Hering** (Elect. World and Engineer, 37. pp. 670–672, April 27, 1901.)—The author points out that arsenic ores are not mined much in the U.S.A., in spite of the high gold values often contained therein, because the arsenic interferes so materially with the smelting operations. In some cases, as in Butte Mont. the arsenic from copper ores escapes up the chimney in the form of white arsenic, which is most harmful to the country around. The new method of electrical reduction, of which the author has made a quantitative test, enables the arsenic to be removed from the ore in the form of metal, leaving the other metallic constituents of the ore in the shape of a matte.

The process is applicable to mispickel or arseno-pyritic ores which contain arsenic in the form of sulpho-arsenide of iron, *i.e.*, according to the formula $FeS_2 + FeAs_2$. The ore when dressed contains 46 per cent. of arsenic. In accordance with the theory, by heating this ore in a closed furnace without access of oxygen, the iron combines with the sulphur, forming the easily fusible ferrous sulphide FeS, while the arsenic distils off as metallic vapour, which condenses into a fine metallic powder. The gold and silver and other metals remain behind as a matte, in which the original percentage of these metals is 80 or 90 per cent. higher owing to the removal of all the arsenic. The process consists in passing an alternating current through a horizontal column of the ore, which conducts sufficiently to allow a heavy current to pass, whereby it is fused. When fused the ore conducts well. The arsenic is removed by a current of nitrogen, which passes through two sets of condensers, one before and one after the furnace, and circulates thus continuously without loss. A reversing valve enables the direction of the current of nitrogen to be changed, whereby a saving of heat is effected by pre-heating the nitrogen in the already hot condenser, on the well-known principle of the regenerative furnace. The arsenic powder is removed

rom the condensers through traps. A tap is provided for drawing off ne fused matte.

In the small furnace used for the experiment, 185 lbs. of ore was fed n per hour, the current varying from 4,000 to 8,400 amperes, and the voltage rom 22 to 12. This is at the rate of 1,140 kilowatt-hours per ton of 2,000 lbs. As, however, the furnace was a small one, and much heat was lost through adiation, this is capable of considerable improvement.

The inventor is G. M. Westman, of New York, who is about to apply he process to some mispickel ore containing on an average 5·75 dollars in old. As there is water power available near the mine, a great saving in the ost of transport is anticipated.

The author finally discusses the best methods of introducing large lternating currents into such a furnace, without heavy losses due to nduction. J. L. F. V.

1755. *Electrolytic Perchlorates.* **F. Winteler.** (Zeitschr. Elektrochem. . pp. 635–642, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—The author's experiments related to the influence of concentration, current-density, temperature, and electrode material upon the efficiency of the cell process when electrolysing chlorate solutions. As egards the effect of concentration, the efficiency remained in all cases about 0 per cent. until the amount of undecomposed chloride present in the olution had fallen to 8 per cent. when a rapid decline occurred.

The experiments with variable current-density and temperature showed hat, at all temperatures, increased current-density produced increased efficiency, while increased temperature produced the inverse effect, namely, a diminished efficiency.

As regards electrode material, polished platinum yielded the best results

The remainder of the paper is taken up with a discussion of the various methods of working a chlorate cell, those of Gall and Montlaur, Oettel, and Müller being referred to. The author used all three methods in an attempt to obtain perchlorates by the direct electrolysis of chloride solutions. His experiments upon this point showed that, whether using diaphragms (Gall and Montlaur's method) or working without diaphragms, no perchlorates were formed so long as 5 per cent. of undecomposed chloride remained in the cell. The formation of chlorate was therefore a necessary intermediate step in the process. J. B. C. K.

REFERENCES.

1756. *Binary Systems: A Theorem of le Chatelier.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 277–280, May, 1901.)—This is a demonstration, by the use of a formula given by van der Waals, of the relation recently established by le Chatelier between the slopes of the concentration curves of two bivariant binary systems under constant pressure at their point of intersection. R. E. B.

1757. *Relations between Atomic Weight, Atomic Volume, and Melting-Point.* **T. Bayley.** (Chem. News, 83. pp. 243–245, May 24, 1901.)—Tables are given exhibiting a connection between the atomic volume and the absolute melting-point of various pairs of elements and the "critical points" considered by the author to indicate the commencement of the various cycles, or, on the hypothesis of atomic condensation from cooling protyle, the temperatures at which the tide of evolution underwent periodic change. T. H. P

1758. *Theorem of Roozeboom.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 281–28 May, 1901.)—This theorem—that, if in a bivariant binary system consisting of liquid solution and a solid solution the addition of a small quantity of one of the com ponents to the liquid phase lowers the temperature of solidification, then the co n centration of that component is greater in the liquid phase than in the solid phase-- is shown to be an immediate consequence of a formula given by van der Waal Further, the protasis of the theorem may be thus stated—if the addition of a sma mass of one of the components to the solid phase lowers the melting-point of tha phase. R. E. H

1759. *Relation between Osmotic Pressure and Work.* **C. Dieterici.** (Zeitsch Phys. Chem. 37. pp. 220–222, May 17, 1901.)—A reply to Noyes [Abstract No. 67 (1901)], objecting to his new definition of osmotic pressure as giving something tha is no *truer* and that is far less easily calculable than that defined by van't Hoff. R. E. H

1760. *Change of Weight in Chemical and Physical Reactions.* **A. Heydweiller** (Ann. d. Physik, 5. 2. pp. 394–420, May 29, 1901.)—This paper contains a detaile account of experiments already described in preliminary note [see Abstract No. 226 (1900)]. T. H. H

1761. *Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 5. 1. pp. 236–239 May 4, 1901.)—The author replies to the arguments of Tammann [Abstract No. 135 (1901)] in favour of the view that the so-called liquid crystals consist in reality o emulsions of one liquid phase in another. T. H. H

1762. *Electrodeposition of Alloys.* **R. A. Lehfeldt.** (Electro-Chemist, pp. 137–139, June, 1901.)—A short account of the principles underlying the electro deposition of alloys and the difficulties still requiring elucidation ; the researche of J. Walter and Cowper-Coles are referred to. N. L

1763. *Electrolytic Regeneration of Chromic Acid Solutions and Manufacture o Diaphragms.* **M. le Blanc.** (Zeitschr. Elektrochem. 7. pp. 653–656, May 30, 190 Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—Supplement t the paper referred to in Abstract No. 540 (1901). Account of the working o diaphragms made of an improved mixture. A. D

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1764. *Angular Displacement of Prime Movers.* **L. Fleischmann.** (Elect. World and Engineer, 37. pp. 920–921, June 1, 1901.)—When alternators are to be run in parallel, it is necessary to specify accurately the permissible maximum angular displacement of the prime movers. An accurate graphical method of doing this from the velocity diagram of a steam engine is given in this paper. Let θ be the actual angle described by a radius of the flywheel in time t, and let ϕ be the angle it would have described had it been moving with the mean angular velocity $\frac{2\pi}{T}$, where T is the period of a revolution of the flywheel; then if ω be its instantaneous angular velocity—

$$\omega = \frac{d\theta}{dt}; \quad \frac{2\pi}{T} = \frac{d\phi}{dt}$$

$$\therefore \omega - \frac{2\pi}{T} = \frac{d(\theta - \phi)}{dt}$$

Hence $\theta - \phi$ is a maximum or a minimum when the angular velocity of the flywheel equals $\frac{2\pi}{T}$, its mean angular velocity.

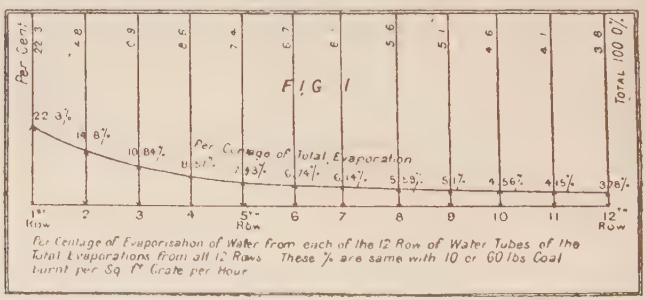
Again— $$\theta - \phi = \theta - \frac{2\pi}{T}\int_0^{\phi} \frac{1}{\omega} d\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Now measure a length OA equal to $\frac{T}{2\pi}$ along OY and a length OB equal to 2π along OX. Through A draw AP parallel and equal to OB. On OB as base construct, from the velocity diagram of the steam engine, a curve having $\frac{1}{\omega}$ and θ for its ordinates and abscissæ respectively, the time being chosen so that this curve passes through A and P. Then this curve will have an equal number of loops above and below AP. If M be the area of a loop whose base is AT, then $\theta - \phi$ is a maximum or a minimum at the point T, and its value is $2\pi \frac{M}{T}$. A. R.

1765. *Steam Engines for Electrical Purposes.* **J. S. Raworth.** (Inst. Elect. Engin., Journ. 30. pp. 971–978, June, 1901. Paper read before the Manchester Section of the I.E.E., March 12, 1901.)—The author points out that while dynamo design tends towards uniformity, there still remains a great diversity of opinion with regard to engines. In England the three-crank high-speed vertical engine is the leading type, while in America slow-speed engines, and on the Continent one-crank engines seem to take the lead. The three-crank engine (*i.e.*, the engine having a compound or triple expansion engine on each crank), has advantages in the matter of vibration; it is, however, not so economical of steam, due to greater leakage length of piston ring, greater area of cylinder walls, and the difficulty of applying automatic expansion. Its turning moment is nearly constant, but with single

or two-crank engines running at more than 200 r.p.m., no practical difficulties arise in respect of turning moment. At Wandsworth there are three 300-h.p. engines with single cranks driving Mordey alternators in parallel at 213 r.p.m. without any trouble. At Bournemouth two-crank engines with the cranks at right angles were once used, but the running in parallel was unsatisfactory. This was remedied by putting the cranks opposite one another. A triple-expansion engine very rarely has any great advantage over a compound engine for electrical work, and with superheated steam the best results are said by Schmidt to be obtained from compound engines. The author thinks that the three-crank three-cylinder compound engine is likely to be much used in the future for large units of from 2,000 to 5,000 h.p., similar to those built by Musgrave for the Glasgow tramways. The l.p. cylinders of such an engine are only slightly larger than the h.p. cylinders, the engine can be easily balanced, has a fairly even turning moment at all loads, and automatic expansion can be applied without difficulty. An engine constructed on these lines, but working at a high speed, would have many advantages. W. H. S.

1766. *Experiments on a Niclausse Water-tube Boiler.* (Engineer, **91**. pp. 339-340, April 5, 1901. Summarised by **Bryan Donkin** from a paper read at the Congrès de Mécanique, Paris.)—In each of these trials made by M. Niclausse, lasting about eight hours each, nine rates of combustion with the same coal were employed from a minimum of 10 lbs. to a maximum of 60 lbs. per square foot of grate per hour. The steam was evaporated in all at atmospheric pressure from a feed-water temperature of 11° C. or 52° F. Both coal and water were carefully weighed. The following were the rates of combustion employed on the trials, viz., 10, 15, 20, 25, 30, 35, 40, 50, and 60 lbs. of coal per square foot of grate surface per hour. At all these rates the percentage of water evaporated from each separate row of tubes in terms of the total evaporation from the 12 rows, remained the same. The boiler was composed of 12 rows of steel tubes, 10 in each



Per Centage of Evaporisation of Water from each of the 12 Row of Water Tubes of the Total Evaporations from all 12 Rows. These % are same with 10 or 60 lbs Coal burnt per Sq ft Grate per Hour

row. External diameter of tubes, 3·23 ins., or 82 mm.; length of each tube, 6·35 feet, or 1·94 m. External surface of each row, 5 square metres or 53·8 square feet; total heating surface, $5 \times 12 = 60$ square metres, or $53{\cdot}8 \times 12 = 645$ square feet. Grate area, 2 square metres or 21·5 square feet. Ratio of total heating to grate surface, 30 to 1. The internal circulating tubes were each 40 mm. or $1\frac{9}{16}$ in. diameter. The calorimetric value of the coal used was 12·91 lbs. of water from and at 212° F. per lb. of coal. Neither the temperature nor the composition of the escaping gases was examined; the tests were merely as to the relative evaporation from each

row of tubes. The plotted results are shown in four diagrams. Fig. 1 (which is here reproduced), gives the plotted results of evaporation from each row in percentage of the total evaporation. The first three rows nearest the fire, with 161 square feet of heating surface, gave nearly 50 per cent. (47·94) of the total evaporation from 645 square feet, the remaining 50 per cent. (52·06) requiring three times the surface.

Fig. 2 gives the evaporative rates from each row of tubes, in lbs. of water per square foot of heating surface per hour, for the nine different rates of combustion. The first row nearest the fire evaporated from a minimum of 8¼ lbs. to a maximum of 34⅓ lbs., whilst the twelfth row evaporated only from 1½ to 6 lbs. per square foot per hour.

Fig. 3 shows the heat-efficiency for each row of tubes at the different rates of evaporation. The lowest rates of combustion yield the highest heat-efficiencies.

Fig. 4 gives the plotted results on a base line of lbs. of water evaporated per square foot of heating surface per hour, with boiler efficiencies as a vertical scale. The curves represent the results obtained from the different rows at the different rates of combustion, and show that the higher rates of combustion and greater evaporation per square foot give less boiler efficiency.

F. J. R.

1767. *Efficiency of Marine Boilers.* **G. M. Brown.** (Mech. Eng. 7. pp. 628-631, May 4, 1901. Abstract of a paper read before the North-east Coast Institution of Engineers and Shipbuilders.)—This paper is a review of the practice during the last twenty years with marine boilers of the cylindrical type with fire tubes, and directs attention to the following points: (1) The waste of heat in producing chimney draught. (2) The use of superheaters. (3) The use of feed-heaters. (4) The advantage of air-heaters. (5) Some devices for increasing heat-absorbing surface. (6) The effects of closing some of the tubes and the advantage of using small tubes. (7) The combination of air-heater and steam superheater in some steamers.

(1) Assuming 700° F. to exist at the base of a funnel 65 feet high, and the atmosphere to be at 62° F., then $w = 0{\cdot}0146\,H - \frac{7{\cdot}66}{T + 461} = 0{\cdot}52$ inch of water, where w = draught in inches of water; H = height of funnel in feet, and T = temperature of the gases. The draught w is distributed as follows:—

	Inch.
Resistance due to the funnel, uptakes, and smokebox	0·02
,, ,, tubes	0·11
,, ,, firebox, bridge, furnace	0·06
,, ,, fire of moderate thickness	0·31
,, ,, inertia of column of gases	0·02
Total	0·52

With coal yielding 14,700 B.Th.U. per lb., and 19 lbs. of air used for combustion per lb., giving 20 lbs. of gases, having an average specific heat of 0.23, then—

$$20 \times 0{\cdot}23\,(700 - 62) = 2{,}934{\cdot}8 \text{ B.Th.U.}$$

(or about 20 per cent. of the heat generated), is used for draught production. To work fans for a consumption of about 30 lbs. of coal per square foot of grate

per hour, about 3 per cent. only are required according to Bertin, or 1·3 per cent. according to John Brown & Co., for their triple-expansion fan engines.

(2) Superheaters were fairly successful with lower steam pressures. At present there is not so much margin for economy. In the ss. *Inchkeith* the boiler pressure is 260 lbs. per square inch, the temperature of the steam at inlet to superheater is about 400° F., the temperature of the waste gases at the smokebox is about 650° F., and above the superheater about 450° F.; with natural draught, the latter temperature would have to be higher.

(3) Reference is made to E. Kemp's feed-heaters and their results (see Trans. Inst. of Engineers and Shipbuilders in Scotland, vol. 32, p. 201), and to the revival of the use of feed-heaters with water-tube boilers.

(4) Howden's, and Ellis and Eaves' plans for heating the air for combustion are referred to.

(5) and (6) The result of C. Wye Williams's experiments with conductor pins (see "The Combustion of Coal," &c. London, 1858, pp. 214–223), and results of experiments with "Serve" tubes and spiral retarders are referred to. The fact that the lower rows of tubes have a much more sluggish draught than the upper rows is made the basis for a form of retarder which reduces the inlet area of the tubes in a diminishing ratio from the top rows to the bottom. Such retarders have been proposed by Hawke, then by West, and latterly by Scott, the latter being described and illustrated.

Isherwood's experiments as to the effect of varying the relation of heating to grate surface by plugging up tubes or inserting ferrules, are quoted; and results of the use of Scott's retarders as compared with spiral retarders and no retarders in the same boiler are given, the average showing 9·7 per cent. saving in coal and 1 per cent. in time in favour of Scott's as against the use of no retarders.

(7) Lastly, the introduction of combined air-heaters and steam superheaters in the ss. *Inchkeith*, *Inchmarlo*, and other steamers is mentioned with some results—the *Inchkeith* having on a trip from Hartlepool to Dover consumed only 0·97 lb. of coal per i.h.p. hour. Further saving is predicted by the addition of feed-heaters to this arrangement.

F. J. R.

GAS AND OIL ENGINES.

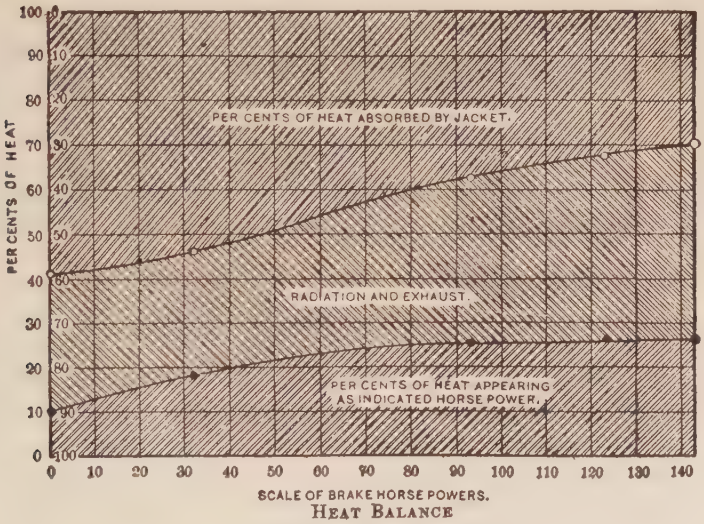
1768. *Test of Westinghouse Gas Engine.* (Eng. Record, 43. pp. 527–528, June 1, 1901. Abstract of a paper read before the American Society of Mechanical Engineers, Milwaukee, by **C. H. Robertson.**)—In previous tests [see Abstract No. 898 (1900)] the engine was not in very good condition; better results are here given of another series of tests upon the same engine after it had been thoroughly overhauled. During a six-hour run, using natural gas to air in the proportion of 1 to 13·7 parts by volume, the average i.h.p. was 113, the highest 142 and the lowest 52. The corresponding b.h.p. was 92, 123, and 31. The frictional loss in engine varied from 15 to 31 h.p., the average being 21. The lowest consumption of natural gas per i.h.p.-hour was 9·7 cubic feet, and per b.h.p.-hour was 11·29 cubic feet. The best thermal efficiency was 157 British thermal units per i.h.p. per minute; and nearly one-quarter of the energy of the gas was realised as work at the flywheel.

Short brake tests, each of 45 minutes, were made to find the distribution of

heat between indicated h.p., the water-jacket, and the exhaust; the following results were obtained with the various loads:—

Duration of test in minutes	40	45	45	45	45
Revolutions per minute	265·5	263·3	261·3	258·3	256·9
Indicated h.p.	18·57	48·48	116·0	143·8	164·2
Brake h.p.....	0	31·4	93·6	123·4	143·2
Frictional loss h.p.	18·57	17·08	22·4	20·4	21·0
Standard gas used per i.h.p.-hour in cubic feet.....	25·8	14·34	10·32	9·87	10·14
Percentage of Heat—					
Converted into indicated work.....	10·2	18·3	25·4	26·6	25·9
Absorbed by water-jacket.....	57·6	53·6	37·0	32·1	29·6
Loss in exhaust and radiation	32·2	28·1	37·6	41·3	44·5

Thus with no load on the brake, the percentages of heat in these three


PER CENTS OF HEAT
PER CENTS OF HEAT ABSORBED BY JACKET.
RADIATION AND EXHAUST.
PER CENTS OF HEAT APPEARING AS INDICATED HORSE POWER.
SCALE OF BRAKE HORSE POWERS.

HEAT BALANCE OF WESTINGHOUSE GAS ENGINE. FIG. 1.

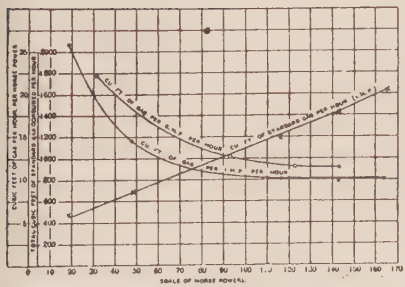
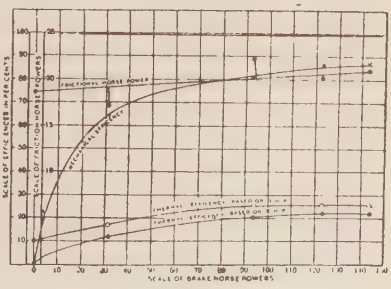


DIAGRAM OF GAS USED.



EFFICIENCIES AT DIFFERENT LOADS.

FIG 2

factors were 10, 58, and 32 respectively. At full load, *i.e.*, 143 b.h.p. or 164 i.h.p., the per cents. were 26, 30 and 44. The chart (Fig. 1) illustrates the

fact that a decrease in loss by water-jacket produces an increase in exhaust loss. The loss by engine friction, average 19·9 h.p., is practically constant, so that the mechanical efficiency increases to 87 per cent. as the load increases. The curves in Fig. 2 show the relation between the horse-power and efficiency of the Westinghouse gas engine. W. R.

AUTOMOBILISM.[1]

1769. *Cottereau Gasoline Vehicle.* (Horseless Age, 8. pp. 154–156, May 15, **1901.** From La France Automobile.)—This vehicle has a rectangular underframe of steel tubing carrying a 5½ h.p. motor in front, a change-speed gear of the Panhard type, but with fixed bevel drive, and a single chain gear to the exterior of the differential on the live rear axle. The engine has two cylinders, each at an angle of 21° from the vertical. The bodies of the cylinders are air cooled with deep radiating ribs, and the heads are water cooled. The cylinders are bolted to an oil-tight crank chamber, the cylinder dimensions are 3¼-inch bore by 4-inch stroke, and the normal speed is 1,000 revolutions per minute. The power is transmitted from the crank shaft through a cone-friction clutch, to the change-speed gear, which, by means of sliding spur wheels, gives three forward and one reverse speed. From the upper shaft carrying the fixed spur wheels, the power is transmitted to a cross shaft by means of a bevel gear. At one end of the cross shaft is a sprocket pinion geared by a chain to a sprocket wheel on the exterior of the differential gear box. The underframe and carriage body is sprung from the axles by long plate springs. Steering is on the Ackerman system. The vehicle is controlled by two hand brakes, one on the cross shaft of the change-speed gear and the other on the differential gear box. C. R. D'E.

1770. *Lane Steam Carriage.* (Horseless Age, 8. p. 153, May 15, 1901.)—This carriage is constructed on the lines now common in American light steam vehicles. The framework of the carriage body encloses and supports a light vertical fire tube boiler and a high-speed vertical engine, together with water and petrol tanks and all accessory parts. The carriage body is sprung from a light tubular underframe, the front tube of which forms the axle, at the ends of which are pivoted the steering wheels, while the back frame tube is split to enclose the halves of the live rear axle, which is driven through the differential gear. The boiler is 16 inches diameter by 20 inches high, and contains 500 vertical fire tubes ½ inch diameter. It is said to steam up to 10 h.p. continuously at 150 lbs. pressure. It is fired by a form of Bunsen furnace using petrol vapour. The supply of petrol is nearly completely cut off by an automatic device when the steam pressure rises above a certain point. The engine has two vertical cylinders, each 3 inch bore by 3½ inch stroke, and runs up to 1,000 revolutions per minute. All the running parts of the engine are enclosed in an oil-tight chamber, which is specially arranged to admit of the chain drive from a sprocket pinion mounted on the crank shaft centrally between the cylinders. This chain drive to the exterior of the differential gear forms the entire transmission, which in these steam vehicles is always very simple. Seven gallons of petrol are carried, which is said to suffice for a run of 35 to 40 miles. The water tank has a capacity of 20 gallons, which suffices for a 20-mile run. The exhaust steam from the engine is led into the water tank and thence escapes into the atmosphere. The weight of the runabout type of carriage is 850 lbs., and of the Surrey type for four persons, 1,250 lbs. C. R. D'E.

[1] Electric Automobiles are described in the section dealing with Electric Traction.

1771. *Motor Vehicles for Heavy Traffic.* **E. Shrapnell Smith.** (Automotor Journal, 5, pp. 403–405; Discussion pp. 405–406, May, 1901. Paper read before the Liverpool Chamber of Commerce, May 6, 1901.)—The author refers to past trials of heavy steam vehicles, and the desirability of increasing the tare limit. He has collected all the obtainable data as to the actual cost of the working of steam lorries in practical use, and from these has compiled the following table :—

ESTIMATES OF THE AVERAGE ANNUAL WORKING COST OF MOTOR WAGGONS, ACCORDING TO ROADS AND LOADS.

CLASS OF WORK.	WEIGHT CAPACITY.	
Per week { 70 hours under steam. 5½ days. 50 weeks per annum.	Self-contained Motor Waggon, 4 tons.	Motor Waggon and Trailer, 7 tons.
Prime Cost	£600	£675
Interest, at 5 per cent. per annum	30·0	33·75
Deprecation, at 15 per cent. per annum	90·0	101·25
Fuel—Furnace coke, at 15s. per ton	63·0	94·5
Wages—Driver, at 35s. per week	91·0	91·0
Assistant, at 17s. 6d. per week	—	45·5
Repairs and adjustments	75·0	90·0
Water, lubricants, and sundries	20·0	25·0
Insurances	12·0	15·0
Total per annum	£381·0	£496·0
Vehicle-miles per annum (280 *days*)—		
(A) On bumpy and badly-paved roads, 30 miles per day	8,400	8,400
(B) On average granite sets, &c., 35 miles per day	9,800	9,800
(C) On good macadam, 45 miles per day	12,600	12,600
Net ton-miles per annum—		
A with full load	33,600	58,600
A ,, ¾ ,,	25,200	44,100
A ,, ½ ,,	16,800	29,400
B ,, full ,,	39,200	68,600
B ,, ¾ ,,	29,400	51,450
B ,, ½ ,,	19,600	34,300
C ,, full ,,	50,400	88,200
C ,, ¾ ,,	37,800	66,150
C ,, ½ ,,	25,200	44,100
Cost per net ton-mile—	d.	d.
A with full load	2·7	2·0
A ,, ¾ ,,	3·6	2·7
A ,, ½ ,,	5·5	4·0
B ,, full ,,	2·3	1·7
B ,, ¾ ,,	3·1	2·3
B ,, ½ ,,	4·7	3·5
C ,, full ,,	1·8	1·3
C ,, ¾ ,,	2·4	1·8
C ,, ½ ,,	3·6	2·7

C. R. D'E.

1772. *Brancher Change-speed Gear.* (Locomotion Automobile, 8. pp. 296–298, May 9, 1901.)—In this article a new and ingenious form of gear is described in which the variation of speed of the driving road wheels is obtained by a system of cranks and levers without the direct interposition of toothed gearing. It is applied to a motor vehicle in the following manner. An engine placed at the front of the under-frame drives a cranked shaft at the back of the driving axle of the carriage by means of a long belt. Between this cranked shaft and the axle, and at a higher level, is another shaft, upon which are pivoted two levers. The back ends of these levers are coupled by connecting rods to the cranks on the shaft driven by the engine. The levers are forked towards their front ends, and between the forks are blocks free to slide along the length of the levers and controlled as to position by means of long screwed rods which work in the blocks. These screwed rods are under control of the driver, and are actuated through a system of spur and bevel wheels, so that by rotating them he can cause the sliding blocks to be screwed up close to the shaft on which the forked levers are pivoted, or to move to the extremities of the levers. On each of the sliding blocks are pivoted two levers, like the blades of a pair of scissors; these levers at their lower ends actuate free-wheel clutches on the driving axle of the carriage. As the rocking levers move upwards, these scissor levers close, and as they descend the scissor levers open and cause the axle to be rotated. According as the sliding blocks are close to or far from the point at which the rocking levers are pivoted, the scissor levers will be given a small or large range of opening and closing movement, and the axle will be turned through a corresponding portion of a revolution per turn of the engine. C. R. D'E.

1773. *Transmission Gear for Automobiles.* **H. Austin.** (Automotor Journal, 5. pp. 382–388, May, 1901. Paper read before the Cycle Engineers' Institute, London, May 9, 1901.)—In this paper the author reviews the chief systems of transmission gear at present employed upon motor vehicles propelled by internal combustion engines. The Panhard, Benz, Peugeot, Dietrich, Renault, Dion, and Wolseley systems are illustrated and described. The analysis of the merits of each system is made under the following headings: (1) Efficiency, (2) Adaptability, (3) Simplicity, (4) Lightness, (5) Durability, (6) Manipulation, (7) Cheapness. The general conclusions of the author are, that in spite of its crudeness, the best method at present available of obtaining change of speed is by spur wheels brought into engagement by side contact. The best method of transmitting the power from the change-speed gear to the driving road wheels is by chain gears to wheels which run independently on a fixed axle. All the shafts should be parallel, and at right angles to the length of the vehicle, so avoiding the use of bevel gearing. The connecting gear between the shafts should, as far as possible, be flexible, so avoiding the necessity of an absolutely rigid under-frame. C. R. D'E.

1774. *Tractive Force Required in Automobiles.* **W. F. D. Crane.** (Elect. World and Engineer, 37. pp. 926–928, June 1, 1901.—The coefficient of traction K, or the resistance to motion, depends on the tyres, the road surface, size of wheels, speed, weight, friction losses in hub bearings, and (in the case of electric cars) in motors and gearing. Other things being equal, K should vary inversely as the diameters of the wheels. On hard roads with iron tyres at slow speeds, K has been found to increase somewhat with speed, but not in direct proportion; width of tyre seems immaterial. Under city conditions, unless the machinery be unusually inefficient, the character and condition of the tyres will be more influential in determining K than the nature and condition

f the road surface. For horse-drawn iron-tyred vehicles, K has been found o have the following values :—

	Lbs. per ton.
Loose sand	320
Good clay roads	98
Cobblestone	54
Best gravel (park road)	51
Poor block pavement	42
Best macadam	38
Poor asphalt	26

The author has made tests of representative electric vehicles to determine (*a*) the gross value of K, including the inefficiency of the motors, friction losses in gearing and hub journals, rolling friction of tyres, electric losses in wiring, &c. ; and (*b*) the net value of K, *i.e.*, the coefficient of traction due to the tyre *per se*. It was assumed in the tests that all pneumatic tyres were fully inflated to about 80 lbs. per square inch for the 2½-inch tyres, 100 lbs. for the 3-inch, and 120 lbs. for the 4 and 5-inch tyres. In the cars tested, the efficiencies of the motors ranged from 79 to 85 per cent., with an average of 81 per cent. Friction losses in gearing were assumed to be 8 to 10 per cent., a figure based on tests of the arrangement of two gears and two pinions, common to all the vehicles. An allowance of 2 per cent. was made in certain cases to cover friction losses in plain sleeve bearings, wiring losses, &c. No account was taken of wind resistance. The results were as follows :—

K in lbs. per ton.		Vehicle.		Sizes and kinds of rubber tyres.	Sizes of Wheels.		City pavements in good condition.
Gross values.	Values for tyres.	Weight in lbs.	Speed m.p.h.		Front.	Rear.	
66	49	1790	14·00	3 in. pneumatic	28	28	Macadam
66	52	1775	13·81	3 ,, ,,	28	28	,,
55	39	2730	12·45	3 ,, ,,	32	36	,,
68	52	3140	11·67	3 ,, ,,	36	36	,,
64	47	1870	15·30	2½ ,, ,,	28	32	Asphalt
64	46	5380	9·00	4 ,, ,,	36	36	,,
54	40	4400	11·20	2½ ,, solid	36	36	,,
48	35	5425	11·15	2½ ,, ,,	36	42	,,
59	43	7240	7·30	3 ,, ,,	38	42	,,
58	42	7240	10·00	3 ,, ,,	38	42	,,
48	36	8480	8·20	4 ,, ,,	38	44	,,
53	38	4150	11·90	2½ ,, ,,	36	42	Macadam
71	51	4300	10·50	5 ,, ,,	36	36	Asphalt
52	37·5	5390	12·60	3 ,, solid in front	36	36	,,
55	39·5	5390	11·90	4 ,, pneumatic in rear			
59	42·5	4150	11·15				
48·5	36	5780	9·75	3 ,, sectional	36	36	,,
38·5	28·5	7900	9·05				

The solid rubber tyres, which show the lowest K, had the shortest lives.

For town roads, a safe figure for K (nett) is 45 lbs. per ton, or say 60 lbs. gross. In country roads, figures may easily be doubled. The tractive h.p. per ton of vehicle is given by the formula—

$$\text{H.p.} = (\text{WSK} \pm \text{W} \times 2{,}000 \times \sin a) \div 33{,}000,$$

where— W = loaded weight of vehicle in tons of 2,000 lbs.
S = speed in feet per minute.
a = angle of grade.
K = coefficient of traction of vehicle in lbs. per ton.

Or we may simplify this to the following :—

$$\text{H.p.} = (WS'K \pm WS'G \times 20) \div 373,$$

where— S' = speed in miles per hour.
G = grade expressed as a percentage.

A table calculated from this formula is given for speeds from 1 to 60 m.p.h., and contains the following results :—

Miles per hour.	Tractive Horse-power per ton.				
	On level.		On grades. (The light figures are the *additional* h.p. per ton on grades. The heavy figures are the total h.p. per ton with K = 60.)		
	K = 10.	K = 60	1 per cent.	5 per cent.	9 per cent.
1	0·026	0·16	0·053 **0·213**	0·266 **0·426**	0·48 **0·64**
5	0·133	0·80	0·266 **1·06**	1·33 **2·13**	2·4 **3·2**
10	0·266	1·6	0·533 **2·13**	2·66 **4·26**	4·8 **6·4**
20	0·533	3·2	1·06 **4·26**	5·33 **8·53**	9.6 **12·8**
40	1·06	6·4	2·13 **8·53**	10·6 **17·0**	19·2 **25·6**
60	1·60	9·6	3·20 **12·8**	16·0 **25·6**	28·8 **38·4**

The gross value of K for any vehicle can be found by use of the above formula, if weight, speed, volts, and amperes are known.

For moderate speeds, air resistance is usually neglected, but for a vehicle weighing one ton and presenting 10 square feet of surface, at 35 m.p.h., the power required to overcome air resistance alone will exceed that required to propel the vehicle on the level with K = 60. The pressure of the wind, blowing at right-angles to a flat surface, is given by $p = 0{\cdot}005V^2$, where p = pressure in lbs. per square foot and V = speed in miles per hour. Thus we get the following table :—

Wind Resistances per square foot.		
Miles per hour.	Pressure in lbs. per square foot.	Equivalent h.p.
5	0·125	0·0016
10	0·50	0·0133
15	1·125	0·0452
20	2·0	0·1066
25	3·1	0·208
30	4·5	0·360
40	8·0	0·853
50	12·5	1·67
60	18·0	2·88

E. H. C.-H.

GENERAL ELECTRICAL ENGINEERING.

1775. *Edison's Alkaline Storage Battery.* **A. E. Kennelly.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 331-342, May, 1901.)—The negative active material of this accumulator consists of finely divided iron; the positive active material of a finely divided superoxide of nickel; and the electrolyte of a 20 per cent. solution of potassic hydrate. On discharge the iron oxidises, while the nickel oxide is reduced to a lower state of oxidisation, but the potassic hydrate takes no part in the ultimate products of discharge at either electrode, and the quantity of electrolyte required is therefore very small. The processes employed for the preparation of the active materials are not indicated, nor the compounds of iron and nickel from which they are obtained; but it is claimed that those actually used are the only ones which will give any results, and that all others can neither be reduced nor oxidised electrolytically in an alkaline solution. The active materials are mixed with a nearly equal volume of flake graphite and moulded under pressure into thin rectangular cakes 3 in. × ½ in. Each cake is enclosed in a very thin sheath of perforated nickelled steel, and they are built up into electrodes by placing a number of them in slots in a thin sheet grid of the same metal and clamping rigidly together in a hydraulic press. The graphite is used to improve the conductivity of the active materials, and does not take any part in the cell reactions. Discharge curves are given of a small experimental cell, and the following figures relate to its performance :—

Initial voltage of discharge after recent charge.....	1·5 volts.
Mean voltage of full discharge about	1·1 „
Normal discharge current per square foot of active element (positive or negative)	8·64 amperes.
Storage capacity per lb. of total cell weight.....	14 watts.

E. J. W.

1776. *Cadmium-Copper Accumulator.* **R. Gahl.** (Zeitschr. Elektrotechn., Wien, 19. pp. 205–206, April 28, 1901.)—The author describes experiments made with a spongy cadmium plate of 0·28 sq. dm. placed between plates of cuprous oxide. The electrolyte was a solution of potash at its best conductivity. The cell was charged and discharged at various rates. The highest e.m.f. obtained was 1·3 volts, but the working value was less than 0·4 volt. With so low a pressure it cannot compete with lead accumulators.

W. W. H. G.

1777. *Lead Burning with Compressed Gases.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 19. pp. 224–227, May 5, 1901.)—The author describes the use of hydrogen and oxygen, compressed in steel cylinders, for lead burning in accumulator manufacture. The gases are compressed to 120 atmospheres, and delivered through a reduction valve made by Dräger of Lübeck. The cylinders are also provided with two manometers, one on the high-pressure side of the valve showing the amount of gas in the cylinder, and one on the low-pressure side for a maximum of 1·5 atmospheres to indicate the pressure of delivery. The best proportion of the gases is 3 of H and 1 of O. A convenient burner for safely mixing and using the gases, also made by Dräger, is illustrated. Electrolytic gases may be used. W. W. H. G.

1778. *Electric Shocks through Water-jets.* **G. Semenza.** (Elect. World and Engineer, 37. pp. 552–553, April 6, 1901.)—In view of the cases in which firemen were reported to have received shocks in directing water-jets on to live conductors, the author carried out some experiments in the laboratory of the Milan Edison Company to determine the minimum length of jet through which a shock is sensible at different voltages. For a jet 12 mm. in diameter a curve is given between pressure and length of jet; at the maximum voltage employed of 3,600 volts, sensation was perceptible through a length of jet of 3½ metres; the shock was, however, quite endurable for a length of 1 metre. At a low potential of 200 volts no sensation was perceptible until the jet was brought to within an inch of the conductor. In the experiments a fireman held the metallic nozzle of the jet with bare hands, and, with wetted boots, stood near to where the circuit was earthed. From these experiments the author concludes it to be impossible for a fireman in ordinary work to receive shocks from any conductor without actually touching the wire with the nozzle. G. H. B.

1779. *Electromagnetic Coils and Plungers.* **R. Kennedy.** (Elect. Rev. 48. pp. 656–657, April 19, 1901.)—The action of a coil on an internal iron core is considered by treating it as an elementary form of motor. The pull on a conductor in a magnetic field is equal to—

$$F = 0{\cdot}00000685\,CB,$$

where F is the maximum drag on conductors in pounds per foot of length, B the induction in c.g.s. lines per square cm., and C the current carried by the conductor in amperes. In the common arc lamp solenoid, B may reach a value of 625, so that with 10 amperes this would give a pull of 0·04 lb. per foot. The cases are separately considered of a plunger equal in length to the coil, of a plunger longer than the coil, and of a core of horse-shoe form. The author finally describes a very powerful coil and plunger, designed for striking a heavy blow. W. W. H. G.

1780. *Automatic Field-regulator for Shunt-wound Dynamos.* **B. Krausse.** (Elektrotechn. Zeitschr. 22. pp. 395–396, May 9, 1901.)—In this arrangement, there is a toothed wheel connected to the switch-arm of the regulating rheostat, and over this wheel are arranged two oppositely-turned feed-pawls mounted below a balance-beam at equal distances from and on opposite sides of the fulcrum, the balance-beam bearing detents for locking the feed-pawls, so that when the balance-beam is horizontal, both pawls will be held out of engagement with the toothed wheel. The balance-beam is actuated by the damped core of a solenoid connected, for example, as a shunt to the dynamo terminals so that, when the core sinks, one pawl will be released and will engage with the toothed wheel and, when the core rises, the other pawl will be released and engage with the toothed wheel. Between the feed-pawls, which are drawn together by a spiral spring, a lever oscillates driven by a connecting-rod and crank from a small flywheel and having a projection for alternately tripping a second pair of detent-levers, also holding the feed-pawls. By this means, when the pressure rises, one pawl will be released, and will swing into contact with and be actuated by the oscillating lever so as to turn the toothed wheel and rheostat-arm in one direction, and when the pressure falls the rheostat-arm will be turned in the other direction in a similar manner by the other pawl. C. K. F.

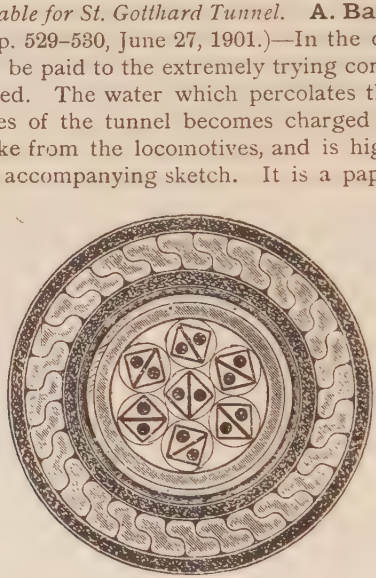
1781. *Switch for Transformers.* **P. Scholtes.** (Elektrotechn. Zeitschr. 22. pp. 361–363, April 25, 1901.)—In this apparatus the main switch of the secondary operates a switch in the primary, and thus the no-load loss is obviated. When the secondary d.p. switch is turned on, a current passes in an auxiliary circuit, including a primary cell and an electromagnet, bridging across one pole of the switch. The magnet moves a trigger which releases an iron weight attached to the primary switch, and at the same time the auxiliary circuit is opened. When the secondary switch is turned off, it momentarily connects across the secondary a solenoid, which pulls up the iron weight and thus opens the primary. At the same time the trigger comes into position, holding off the primary switch and closing one of the two gaps in the auxiliary circuit. The primary is switched off after the secondary, and hence the primary current at breaking is very small. The apparatus is stated to be cheap, and effective in practice. It is made by Schuckert. W. H. E.

1782. *Electromagnets for Lifting.* **E. B. Clark.** (Amer. Electn. 12. pp. 558–560, 1900, and 13. pp. 64–67, Feb., 1901.)—The conditions favourable for the use of lifting magnets, on cranes and other hoists, are most frequently met with in rolling mills, boiler shops, and locomotive repair shops. The material to be lifted must have a fairly smooth surface to which the magnet may be applied. During several years' experience the writer has never known of any accident occurring through unexpected dropping of material. The magnetisation of the polar face should not be carried much beyond B = 16,000, giving 150 lbs. per square inch. The best form of the magnet depends on the class of work. For plate work a group of rectangular poles answers well. To regulate the number of pieces lifted, the switch should be opened for an instant and then closed again, one or more pieces being thus dropped as required. In order to lessen the effects of self-induction, a non-inductive resistance may be joined in parallel with the magnet coil, on the dead side of the d.p. switch. When extra lifting force is required the series-parallel arrangement may be applied to the winding. A magnet to lift 3,000 lbs. of plates should work with about 1,000 watts, and under favourable conditions such a magnet would lift 10,000 lbs. if the poles fit the material accurately. For cranes used in handling steel plates, the author recommends a magnet made up of, say, twelve poles 3½ inches long and 1 inch by 5 inch cross-section, bolted to a soft-steel plate. On the top of this plate is bolted a smaller one, having an eye riveted to it for supporting the magnet. Each pole is wound to a depth of ¾ inch, no bobbin being required. The poles are arranged in two rows side by side, with poles alternately N and S. This arrangement is for lifting long plates, for which purpose several such magnets may be hung from a long bar. To lift a pile of several small plates at once, the poles should be so arranged as to form practically two large poles, N and S, some distance apart. A magnet on these lines, weighing 300 lbs., lifts 27 times its own weight and requires 4·4 amperes at 250 volts. W. H. E.

1783. *Electrical Tide Indicator.* **G. H. Powell.** (Elect. World and Engineer, 37. pp. 861–862, May 25, 1901.)—A vertical base system of range finding, as required for the guns of a fort on the coast, demands a knowledge at all times of the height above the level of the sea. Hitherto a simple float actuating a hand on a large dial has sufficed. A. Le Blanc has devised an electrical arrangement which is more convenient. The potentiometer principle has been adopted. Between the terminals of a resistance of

120 ohms a constant p.d. of 10 volts is maintained by means of a battery. One end of the resistance is connected with one terminal of a 10-volt voltmeter, the other terminal of which is connected to the slider that is actuated by a float. By providing a suitable scale on the voltmeter the height of the tide is given directly. In the instrument actually constructed the slider is fixed and the resistance moves, being attached to a wheel which is caused to turn as the tide rises or falls. The details of the construction of this resistance are illustrated. W. W. H. G.

1784. *Telephone Cable for St. Gotthard Tunnel.* **A. Baechtold.** (Elektrot. techn. Zeitschr. 22. pp. 529–530, June 27, 1901.)—In the design of this cable special regard had to be paid to the extremely trying conditions to which the cable would be exposed. The water which percolates through the rock and trickles down the sides of the tunnel becomes charged with the acid fumes contained in the smoke from the locomotives, and is highly corrosive. The cable is shown in the accompanying sketch. It is a paper- and air-insulated



cable manufactured by Felten and Guilleaume. Each conductor is 1·8 mm in diameter. There are seven two-wire circuits, each of which is covered with paper tape to a diameter of 7 mm. The seven circuits are stranded together and covered with a triple covering of cotton. A double tin-lead sheathing surrounds the conductors and protects them against the chemical action of the water and acid fumes. Outside the lead sheathing is a layer of compound, and then comes a strong steel armouring of 28 wires, of the special cross-section shown in the sketch. Finally, there is an outer coating of jute yarn soaked in a protecting compound. The external diameter of the cable is 44 mm. A. H.

1785. *Electric Harbour Cranes at Hamburg.* **E. Krautschopp.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 654–657, May 11, 1901.)—On the quays at Hamburg there are sixty electrical cranes of from $2\frac{1}{2}$ to 3 tons capacity. The author gives figures showing the power required by them for lifting various loads through various heights, and in particular he deals with the efficiency of the various types. There are six types in all; particulars are given of all of them, showing the methods of regulation, and also the sizes of the motors working them. All are worked by two motors, one for lifting and one for turning. The figures also show the weights unloaded by these cranes and the units consumed during the year 1899 and the first half of 1900; but the height through which the weights were raised or lowered are not stated. It appears

However, that the best performance was that of a crane which unloaded about 10·2 tons on an average for an expenditure of 1 kw.-hour ; the average height of lift would *appear* to be about 25 feet, the crane being then swung through about 140°, and the load lowered to the ground through a distance of about 20 feet. The author considers that the figures prove : (1) that it is better to use motors too small than too big, and to overload them for short periods, if necessary ; (2) that the weight of the hook and block should be sufficient to allow the chain to descend without the use of current ; (3) that the use of mechanical brakes is liable to lead to waste of energy, inasmuch as there is a tendency on the part of drivers in cold weather to warm themselves by means of the radiated heat from resistances, &c., while regulating the speeds mechanically. The author considers that in the matter of gearing, raw hide pinions are unnecessary. The Union Electricity Company, of Berlin, supplied gearing consisting entirely of steel, very carefully finished, and with proper lubrication the noise is not excessive. Automatic regulation of the height of lift and angle of turning is found by experience to be unnecessary. The cost of working by electricity is not notably lower than that of working by steam, and such small reduction as exists is almost exactly counterbalanced by increased prime cost.

Drawings and descriptions of cranes, similar to those under discussion, reconstructed by Mohr & Federhaff, and exhibited at the Paris Exhibition, appeared in the Zeitschrift des Vereines Deutscher Ingenieure of June 22, 1901, pp. 874–883. W. H. S.

REFERENCES.

1786. *European Electrical Developments.* **W. J. Hammer.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 105–180, Feb., 1901.)—A paper dealing generally with several modern inventions, &c., including the telephonograph, the Nernst lamp, the osmium lamp, several types of gas and other engines, the Langen mono-rail system, three-phase traction lines, and other developments.

1787. *Automatic Cut-out Switch.* **F. Natalis.** (Elektrotechn. Zeitschr. 22. pp. 318–320, April 11, 1901.)—Description of a new automatic cut-out switch brought out by Schuckert & Co. It is fitted with large carbon contacts and made in seven sizes, ranging from 100 to 2,000 amperes. Three photographs and three line-drawings are given showing details of the construction. E. K. S.

1788. *Carbon for Electrotechnical Purposes.* **J. Härden.** (Elektrotechn. Zeitschr. 22. pp. 320–326, April 11, 1901.)—This article contains a large amount of information as to the methods adopted in the preparation of carbon in its different forms, including the manufacture of electrodes for electrolytic purposes, arc-lamp carbons, carbons for use in the electric furnace, and carbon brushes for dynamos. The author describes tests by which the carbons may be examined in order to ascertain whether they are suitable for the special purposes for which they are intended to be used, and gives figures which he has obtained as the result of these tests. W. H. S.

1789. *Primary Cells with Internal Heating.* **W. S. Rawson.** (Elektrochem. Zeitschr. 8. pp. 25–26, May, 1901.)—This paper describes a cell for molten metals and salts, with arrangement for heating by the introduction of producer or other gases. G. H. B.

1790. *Data of Accumulators.* **J. H. West.** (Electro-Chemist, 1. pp. 70–72, March ; 96–99, April ; and 116–118, May, 1901.)—Tables are given of weight, volume, discharge-rate, and price of various accumulators.

GENERATORS, MOTORS, AND TRANSFORMERS.

1791. *Magnetic Attraction in Armatures.* **E. Knowlton.** (Elect. World and Engineer, 37. pp. 969–970, June 8, 1901.)—Owing to wear of the bearings it is seldom that the armature and the magnetic field of a dynamo are concentric. Calculations are made and formulæ arrived at for the total vertical resultant attraction on the armature when the dynamo has any number of poles. If B be the normal flux density in lines per square inch of a pole face, A the area in square inches of the pole face, g the average normal air-gap in inches, a the normal reluctance of one air-gap, b the normal reluctance of one-half the complete circuit between two neighbouring poles, d the displacement of the armature in inches, and P the vertical pull in pounds, then—

$$P = \gamma \frac{B^2 A}{72,134,000} \frac{ad}{bg}.$$

For a four-pole machine	$\gamma = 2$,
„ six- „ „	$\gamma = 4{\cdot}7$,
„ eight- „ „	$\gamma = 7$,
„ ten- „ „	$\gamma = 9{\cdot}6$,
„ $2n$- „ „	$\gamma = 2n$,

provided that n be greater than 5. A. R

1792. *Winding Formulæ for Drum Armatures.* **W. B. Burnie.** (Electrician, 47. pp. 220–222, May 31, 1901.)—Let y_1 and y_2 be the algebraic spacing numbers, that is, if the back connection is from 1 to 18 and the front connection 18 to 3, y_1 and y_2 will be 17 and -15; m the number of entirely independent circuits, n the number of mutually re-entrant circuits, $2p$ the number of poles, N the number of conductors, $b = p$ or 1, according as the armature is series or parallel connected, then—

$$\tfrac{1}{2}(y_1 + y_2) = m\left(\pm \frac{N}{2pm} \pm \frac{n}{b}\right),$$

$\frac{N}{2pm}$ being omitted when lap-winding is used. The value of $y_1 - y_2$ depends on whether we use chord-winding; putting aside chord-winding for the time $y_1 - y_2 = 0$ for wave-winding, and $= \pm \frac{N}{p}$ for lap. Taking as an example a wave-wound duplex six-pole drum with 102 conductors parallel connected—

$$n = 2,\ m = 1,\ b = 1,\ p = 3,\ \tfrac{1}{2}(y_1 + y_2) = \pm \frac{102}{6} \pm \frac{2}{1} = \pm 15 \text{ or } \pm 19.$$

A particular type of winding can be made out of a given number of conductors, if $\frac{1}{2}(y_1 + y_2)$ is a whole number and the winding is not self-re-entrant before reaching the point where it should be, that is, if $2m$ is the highest common factor of $y_1 + y_2$ and N. For chord-winding the value of $y_1 - y_2$ must be the nearest even number to the fractional or whole number given by the formulæ above. The author gives several more examples of different windings. R. B. I

1793. *Design of Large Generators.* **A. Heyland.** (Zeitschr. Elektrotechn. Wien, 19. pp. 293–296, June 16, and 305–308; Discussion, pp. 308–310, June 2

1901. Paper read before the Elektrotechn. Verein, April 24, 1901.)—The author briefly reviews the general principles underlying the design of large modern generators, and compares continuous with alternating-current machines. The maximum output is secured by making the width of the teeth equal to that of the slots. The slots of continuous-current machines should preferably be wide and shallow, the armature reaction may be relatively large (the ratio of field to armature ampere-turns being sometimes equal to unity), and the pole-pieces or pole-shoes should be laminated. In the case of alternators, on the other hand, the windings should preferably lie in tunnels, or else the tops of the teeth should be expanded so as almost to touch each other; armature reaction should be small (ratio of field to armature ampere-turns varying from 3 to 5), and the pole-pieces and pole-shoes should be solid, so as to provid a sufficient amount of damping to prevent hunting. In order to secure stability, the field-cores of dynamos should be worked at a high induction—about 17,000. The peripheral velocity is from 10 to 15 metres per second in the case of continuous-current machines, and 30 metres per second in the case of alternators. A. H.

1794. *Heating of Electrical Machinery.* **E. R. Douglas.** (Elect. World and Engineer, 37. pp. 769–772, May 11, 1901.)—The author gives a mathematical discussion of the problem of the rating of electrical machinery to be used with loads which fluctuate in any regular manner. It is obvious that smaller machines can be used for fluctuating loads than could be used if the load remained at its maximum value throughout. The formulæ given were worked out originally for the Crocker-Wheeler Company, and were tested experimentally with satisfactory results. By measuring the temperature-rise of the coils under various conditions of load, a set of constants is determined for each machine which enables its performance under any regularly recurring loads to be predicted. The rise of temperature for the case of a slow alternation between two conditions of load is considered and an exact solution found. When the period of fluctuation is less than five minutes, an approximate simple formula is given. A. R.

1795. *Dynamo Losses.* **W. Peukert.** (Elektrotechn. Zeitschr. 22. pp. 393–395, May 9, 1901.)—Dynamo losses consist of friction, eddy current, and hysteresis losses. Kapp and others have assumed that frictional losses are proportional to the speed; but Dettmar has shown that they increase more rapidly than the speed. [See Abstract No. 1775 (1899).] According to Dettmar's method, the frictional losses are determined by observing the rate at which the machine, after being brought up to speed, slows down when left to itself, and when running without load or exciting current. Thus we have the equation—

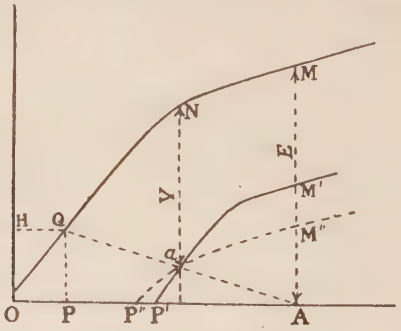
$$R = \frac{C}{t}(v_1^2 - v_2^2),$$

where R is the energy dissipated by friction in a second, v_1 is the initial speed, and v_2 is the speed after a time t, C being a constant that must be determined for each machine. The speeds can be determined by a voltmeter, which shows the voltage of the machine generated by the residual magnetism, a curve connecting the speed with such voltage having been constructed beforehand. Similarly the other losses of the machine can be included and determined by this method, supposing that the magnets remain excited during the period of slowing down. The author experimented with a motor taking

26 amperes at 440 volts, and drew curves showing the rate of slowing down, when the machine was run (1) with no excitation, (2) with one-quarter, (3) with one-half, and (4) with full excitation. The machine was brought up to speed by a small motor, which was then disconnected. The constant C was determined by running the machine with full excitation on no load, and observing directly the power required. By comparison with earlier observations, the constant C was calculated, and the mean of several calculations (which are given throughout in full) in the case of this machine gave its value as 0·006. The previous curves are then corrected so as to give the connection between the losses in watts and the speed at any instant. Finally, the author dissects the losses in one particular case in a manner similar to that proposed by Kapp in 1891. It is stated that the tests can be carried out in a short space of time, and they have always given satisfactory results in the author's laboratory. W. H. S.

1796. *Insulating Armature Stampings with Graphite.* **F. Leconte.** (Électricien, 21. pp. 201–203, March 30, 1901.)—Blacklead is a sufficiently bad conductor for this purpose, and it has the advantage that it is exceedingly cheap and easily applied by machinery. It gives 4 per cent. increase in the quantity of iron which can be packed in any volume (compared to paper insulation). Four per cent. less watts were wasted in running a small graphite-insulated armature on open circuit than when paper-insulated. M. O'G.

1797. *Leakage Reactance of Alternator Armatures.* **A. Blondel.** (Elektrotechn. Zeitschr. 22. pp. 474–475, June 6, 1901.)—The author describes a simple method for separating the effect of armature reaction from that of leakage reactance. Let QNM be the open-circuit characteristic, AM corresponding to the open-circuit e.m.f. due to the ampere-turns OA. Let the short-circuit current corresponding to the same excitation be I_s, and the



leakage reactance ω. Then $\omega I_s = OH = PQ$ is the e.m.f. required to balance the leakage counter-e.m.f. In order to produce this e.m.f., an effective excitation represented by OP ampere-turns is required; hence AP gives the back-turns of the armature. If now the machine is allowed to work on an inductive load (power-factor = 0) with a current $I_l = aI_s$, the terminal p.d. is easily found by laying off $Aa = aAQ$, and drawing aN parallel to the axis of e.m.f.; aN gives the terminal p.d. This construction suggests a simple experimental method of finding ω and the factor K which converts armature current into armature back-turns. Find the open-circuit and short-circuit characteristics, and the terminal p.d., V, corresponding to

any current $I_l = aI_s$ when the machine is working on an inductive load. Plot a curve $P''aM''$ which is the open-circuit characteristic QNM lowered by an amount = V. Further, plot another curve, $P'''aM'''$, similar to QNM, the point A being the centre of similarity. The intersection a of these two curves determines the line AQ, and PQ = OH. Hence $\omega = \frac{PQ}{I_s}$; and $K = \frac{AP}{I_s}$. The point M must be chosen beyond the knee of the open-circuit characteristic. A. H.

1798. *Effect of Peripheral Velocity on Dimensions and Weight of Three-phase Generators.* **A. Siewert.** (Elektrotechn. Zeitschr. 22. pp. 462–465, June 6, 1901.)—In this investigation, the author assumes that the revolutions per minute, the frequency, the inductions in air and iron, the flow of current per cm. length of armature periphery, and the ratio of pole-arc to pole-pitch are given, and considers how the weight and external dimensions of the machine depend on the peripheral speed. He finds that a reduction of weight with increase of peripheral speed can only be obtained if the output of the machine is not too small. A. H.

1799. *Distribution of Potential in Short-circuited Three-phase Generators.* **E. Rosenberg.** (Elektrotechn. Zeitschr. 22. pp. 357–361, April 25, and 377–379, May 2, 1901. Report read before the Hanover Elektrotechn. Verein, Jan. 22, 1901.)—When a single-phase alternator is short-circuited, the e.m.f. in any section of the armature-winding is balanced by the fall of potential along the same section. In the case of star-connected three-phase generators, this statement does not hold good. Experiment shows that there may then be a considerable p.d. between the neutral point of the winding and the short-circuiting conductor, and that if these two be connected by a stout conductor (an ammeter being included in the circuit), a considerable current will flow through this conductor. Curves obtained with several different machines are given which exhibit this effect very clearly. The explanation is to be found in the presence of a third harmonic in the e.m.f. wave. The author describes a number of experiments, all of which go to prove the fact that the frequency of the current obtained in the conductor connecting the neutral point with the short-circuiting conductor is three times the frequency of the current in each phase. A detailed graphical discussion of the effect is given. In the directions issued to fitters, it is frequently stated that when running the machine on short-circuit, in order to heat up the coils before a test under load, the rise of temperature may be estimated by placing the hand in contact with the coil, and that there is no danger in doing this. The author points out that in the case of many three-phase machines such a procedure might be attended with danger to life. A. H.

1800. *Voltage-Drop in Three-phase Alternators.* **J. Rey.** (Ind. Élect. 10. pp. 221–227, May, 1901.)—The author calculates the voltage-drop in a three-phase inductor machine and compares his results with those obtained by experiment. The theory he adopts is that of "two reactions" worked out by Blondel. [Abstracts Nos. 336 and 337 (1900).] The total magnetic flux is supposed to be the resultant of two fluxes, one due to the ampere-turns in the inducing circuit and the other due to the ampere-turns in the induced circuit. The flux induced by the latter is resolved into two components, one due to the "wattless" and the other due to the "watt" current: the former current differs 90° in phase from, and the other is in phase with, the total induced

e.m.f. The flux induced by the wattless current is in direct opposition to the phase of the total e.m.f., and its effect can be expressed by a certain number of demagnetising turns. On the other hand, the watt current gives rise to a transverse magnetic force, and the flux has to be calculated from the reluctance of a different magnetic circuit. The effect of this transverse flux is analogous to self-inductance. The 60-kw. machine experimented on gave a p.d. of 3,000 volts per phase. There were three air gaps in the magnetic circuit, and so Blondel's theory was severely tested. All the dimensions and calculations are given in full, the slots being taken into account and the variation of the reluctance for various positions of the inducing poles duly noted. The direct reactance varied between 178 and 213 ohms, whilst the transverse varied between 117 and 136 ohms. The mean of the first two and the mean of the last two figures were taken in making the calculations. The following results show that the theory was very approximately correct for this machine on a non-inductive load.

Exciting Current in Amperes.	Main Current in Amperes.	P.D. at Terminals per Phase in Volts.	Total e.m.f. calculated by Two-Reaction Theory.	E.m.f. measured from characteristic on Open Circuit.	Percentage Error.
11·2	3·98	2020	2276	2240	+1·6
14·8	4·71	2410	2730	2730	0
17·8	5·08	2640	3010	3020	−0·3
20·0	5·35	2780	3170	3180	−0·3
25·0	5·55	2900	3330	3380	−1·5

A. R.

1801. *Compounding of Alternators by Compensating Exciter.* **E. J. Berg.** (Elect. World and Engineer, 37. pp. 676-678, April 27, 1901.)—This is a description of a device, due to E. W. Rice, jun., which consists in directly connecting an exciter synchronously with the generator and exciting this excifer by the current from the alternator. An alternating current supplied to such exciter armature will magnetise the machine and cause it to give any desired direct-current voltage, which depends not only upon the magnitude of the current, but also upon its phase relation to the field poles. W. G. R.

1802. *Polyphase Substation Machinery.* **A. C. Eborall.** (Inst. Elect. Engin., Journ. 30. pp. 702–753 ; Discussion, pp. 753–772, May, 1901.)—Polyphase substations can be divided into three classes, viz. : (1) those employing asynchronous motor-generators ; (2) those using synchronous motor-generators, and (3) those using rotary convertors. Of these, the first are the simplest both in design and operation, and the third are the most complicated, owing partly to the necessity of transforming the pressure before putting the current through the rotaries and to the nature of the regulating devices. The methods of starting the various types of machine are considered in detail. [See also Abstract No. 2102 (1900).] With rotaries there is an advantage in connecting the transformers in mesh, because if one transformer should blow its fuse, the other two will continue to supply three-phase current to all three phases of the rotary. If the transformers were connected in a star, single-phase current only would be delivered, and the rotary would probably have to be cut out owing to sparking on the commutator.

The six-phase connection for rotary convertors is desirable, seeing that the output of a six-phase rotary is from 40 to 50 per cent. greater than that of a three-phase rotary, allowing the same mean heating in the armature coils. The connections for this system are illustrated by diagrams, but admittedly the arrangement is complicated. For regulating the pressure of rotaries, two methods are available : (1) a method by which the impressed pressure is varied by an induction regulator, which is conveniently done by hand in the case of a lighting load ; and (2) a system of compound winding of the rotaries, which is more suitable for the case of a traction load. Both these methods are fully explained and discussed. Substation machinery of the synchronous type has the great advantage that the lagging current can be controlled by varying the excitation, and that it is smaller in amount than with the asynchronous type. The connection of this matter with the design of the machine is explained by the aid of curves which show the performance of a synchronous motor-generator made by Kolben for the Prague tramways. Drawings are also given of this and other machines. Synchronous motors should be so designed that, when run as generators, they have a drop at full load at 5 or 6 per cent. with a power-factor of 100 per cent., and of 18 to 20 per cent. with a power-factor of 80 per cent. The question of parallel-running and hunting is of importance. Difficulties often arise from the cyclic irregularity of the engines, and the author considers that the Horn tachograph (sold by Berend, of London) should be more widely used by engine-builders and others in this country. Curves taken by this instrument are reproduced, showing the variations in speed of an engine while its governor was undergoing adjustment. In designing the engine-room plant, the better plan is to place the generator between the cranks, which should be at 180 degrees apart. On the Continent horizontal engines are being standardised with tandem cylinders and one crank. This arrangement gives the fewest points of maximum and minimum speed per revolution. The amount of cyclic irregularity, with rotary converters for example, should be such that the phase-displacement at any time should not exceed 2 degrees, that is to say, a point on the rotating magnet should not differ by more than $2/p$ degrees from the position it would have if the rotation were perfectly uniform, $2p$ being the number of poles. The machines themselves help to increase any irregularity of speed under various conditions, and the armature oscillations should, therefore, be damped as soon as they arise. For this purpose the author recommends damping coils, which bridge the poles of synchronous motors and rotaries by copper plates. He considers that it is of relatively little use to put the damping coils round the pole-pieces ; this view was, however, considered unsound by some of the speakers in the discussion, while others favoured the use of Leblanc's "amortisseurs." Synchronous motors, on account of armature reaction, are less liable to hunt than rotary converters ; but this is also due partly to the fact that the fields are fed at a steady pressure, independent of the pressure on the feeders. As the result of hunting, the current in the high-pressure feeders pulsates ; at Prague this has been obviated by the insertion of choking coils in the feeders. When working at no load without choking coils, the fluctuation of pressure was about 3 per cent. ; when the coils are in circuit, no fluctuation can be detected. With a choking coil for use with a 900-kw. machine, the loss at full load in the coil was 800 watts, and the pressure drop was about 2 per cent. Finally the author gives a table comparing the various types of machinery for substations from the point of view of the performances of the machines, in so far as these can be numerically dealt with. This table is reproduced on the next page.

COMPARISON OF SUBSTATION MACHINERY.

Transmission : Three-phase at 5,500 volts between lines and 40 cycles.
Distribution : Three-wire at 510 volts between outers, neutral conductor earthed.

Type of Equipment.	Asynchronous Motor generator.		Synchronous Motor generator.		Rotary Converters and Step-down Transformers.	
Output of substation converter	150 kw.	500 kw.	150 kw.	500 kw.	150 kw.	500 kw.
Speed of converter...	480	300	480	300	480	300
Number of field-poles (generator) ...	6	10	6	10	10	16
Peripheral speed of commutator ...	1760	1880	1760	1880	2970	3100
Number of commutator bars	162	270	162	270	400	560
Temperature rise, any part after 24 hours at full load...	35° C.	35° C.	35° C.	35° C.	35° C.	35° C.
Rise of pressure when full load switched off, sub-station bus-bar pressure constant	15%	12%	14·5%	11·5%	9·5%	8%
Efficiency { Full load	83·5%	86%	84%	87%	90%	92%
Efficiency { Half „	75·5%	80%	76%	79%	85%	87·5%
Overload capacity for one hour with fixed brushes ...	25%	25%	25%	25%	50%	75%
Power-factor { Full load	90%	91%	100–95% (leading)	100–96% (leading)	100–95% (leading)	100–96% (leading)
Power-factor { Half „	87%	88%				
Starting current from A.C. side in terms of full-load current	80% (Rotor resistance.)	50% (Rotor resistance.)	100% (Starting motor.)	100% (Starting motor.)	80% (Starting motor.)	60% (Starting motor.)
Full load drop of speed	3·5%	3%	None	None	None	None
Relative cost per kw., including regulating gear ...	20	15·6	19·1	13.2	12·4 (Including middle wire booster.)	13·0 (Including middle wire booster.)
Floor space required per kw. (square feet)	0·8	0·5	0·75	0·5	0·55	0·45

W. H. S.

1803. *Resistance of Squirrel-Cage Rotor.* **J. Heubach.** (Elektrotechn Zeitschr. 22. pp. 430–432, May 23, 1901.)—The paper contains a very elegant method of investigating the apparent increase in resistance of the rotor bars which is due to the resistance of the end-rings. It is assumed that the

pace-distribution of the magnetic flux follows the simple sine law. The author first supposes that the resistance of the rings is negligible. The current flowing in each rotor bar will in this case simply correspond to the e.m.f., and we accordingly get a sine-distribution of currents. He next assumes the whole of the resistance to be in the end-rings, the bars being without resistance. If we suppose the whole of the resistance to be concentrated in one ring, the resistance of each segment of this ring must, for the purposes of calculation, be assumed equal to double its actual resistance, and the p.d. across a segment of the ring between two neighbouring bars will equal the difference in the e.m.f.'s induced in these bars. The law according to which the currents are distributed in the end-rings is thus obtained. A combination of these two ideal cases corresponds to the actual rotor. Using this method, the author shows that if R_b is the resistance of a rotor bar, and R_r = that of a single segment of the ring, then the current in each bar is that corresponding to a resistance—

$$R_b + \frac{R_r}{2 \sin^2 \frac{\alpha}{2}}$$

where α is the angle of phase-difference corresponding to the angular distance apart of two consecutive bars. He then applies this result to determine the best way of arranging a given amount of copper, and shows that if Q = cross-section of ring, and q = cross-section of bar, then the least resistance is obtained by making $\frac{Q}{q} = \frac{1}{2 \sin \frac{\alpha}{2}}$.

A. H.

1804. *Frequency Converters.* **A. S. McAllister.** (Elect. World and Engineer, 37. p. 763, May 11, 1901.)—The adoption of a frequency of 25 for power transmission has led to the use of "frequency converters" when the supply is to be used for lighting. The frequency converter consists practically of a combined synchronous and induction motor. The supply current is derived from the rotor of the induction motor which is driven backwards by the synchronous motor. If a load of W kilowatts is to be changed from a frequency p to a frequency q, then the capacity of the induction motor should be $\frac{p}{p+q}$ W, and of the synchronous motor $\frac{q}{p+q}$ W. It is to be noted that the iron loss in the rotor will now be the same as that of a generator whose capacity is W kilowatts and frequency q. Hence it will be an appreciable quantity.

A. R.

1805. *Rotary Converters.* **de Marchena.** (Soc. Int. Élect., Bull. 1. pp. 205–244; Discussion by **P. Janet,** pp. 244–245, May, 1901.)—The ratio of the direct and alternating current voltages, the heating of the armature, and the armature reaction are calculated for all cases. It is proved that when the number of phases is infinite and the current is in phase with the applied e.m.f., then the armature reaction is zero. When the angle of phase-difference between the current and the e.m.f. is ϕ, then the wattless component I sin ϕ produces a magnetising force in the same direction as that produced by the exciting coils. This magnetising force tends to strengthen the magnetic field when the current is lagging and to weaken it when the current is leading. Hence in a converter, as in a synchronous motor, strengthening the field makes a leading current and weakening the

field makes it lag. The author develops this analogy, and points out that it is possible to make converters which will act without excitation. The capacity of such machines would be small, as the current would need to lag by a considerable angle. In practice the number of phases is limited, and hence the magnetic field is not constant. For a single-phase converter the field produced by the armature is a pulsating one whose frequency is double that of the current supplied. When there are n slip-rings the frequency of the pulsations is n, but their amplitude diminishes rapidly with n. The stability of converters and their capacity to stand overload is favourably commented on. A mathematical discussion is given of their regulation, and it is shown theoretically and by experimental results with a 300-kw. converter that practically constant volts at all loads can be obtained by putting a regulating induction coil in series with the converter. To prevent "hunting," copper plates should be put between the poles, and the converters ought never to be started directly in parallel without special devices to prevent a rush of current. A. R.

REFERENCES.

1806. *Rotary Converters and Motor Generators.* **F. C. Perkins.** (West. Electn. 27. pp. 364–365, 380–381, 396–397, and 412–413, 1900.)—An illustrated account of the various uses of these machines. W. H. E.

1807. *Calculation of Leakage Coefficients of Induction Motors.* **J. Jones.** Elektrotechn. Zeitschr. 22. pp. 448–451, May 30, 1901.)—The author develops formulæ for the leakage coefficients of induction motors, taking the case of slotted cores. The method used in deducing the formulæ is explained in detail, and several interesting examples of the application of the formulæ to actually constructed motors are given, which show that the calculated values agree very closely with those found experimentally. A. H.

1808. *Formulæ for Leakage Inductance in Alternators.* **Niethammer.** Elektrotechn. Zeitschr. 22. pp. 475–476, June 6, 1901.)—The author gives a theoretical formula for the leakage inductance, and proceeds to show how the theoretical values for the constants entering into the formula have to be modified in order to bring them into agreement with experimentally determined values. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1809. *Polyphase Equipment of Factories.* **W. Wyld.** (Inst. Elect. Engin., Journ. 30. pp. 986–1011; Discussion, pp. 1012–1019, June, 1901. Paper read before the Birmingham Section of the I.E.E.)—The author deals with the advantages and disadvantages of polyphase motors for workshop purposes, and considers them to give as good results as continuous-current motors. He gives a list of sixteen polyphase installations in this country, and describes more particularly that of the Patent Shaft and Axletree Co., Wednesbury. In this factory the generators, which are star-wound, give current at 350 volts; the lighting is, however, carried out at 200 volts by connecting the lamps to the neutral wire and one or other of the main cables. The load-factor is 42 per cent., and with an output of 554,000 units in the year, the cost of generation, including coal, water, wages, oil, and stores is 0·552d. per unit, and the cost of distribution, *i.e.*, the wages of motor attendants, crane men, arc-lamp trimmers, &c., amounted to 0·215d. per unit, making a total of 0·767d. per unit. The works contain two travelling cranes, the speeds being controlled by resistances introduced in series with the rotors. Ten additional cranes are to be similarly fitted with motors and controllers. The author, in conclusion, gives a long list of factories abroad which are worked by polyphase motors, adding at the same time concise particulars about each.

Discussion.—**W. E. Sumpner** said that owing to the absence in polyphase motors of exposed parts connected to the mains, a higher voltage than that used with direct-current motors was equally safe, and that the advantage as regards economy of copper for distribution in factories lay decidedly with polyphase systems. **H. D. Wilkinson** said that in collieries, and places where the current had to be conveyed over any considerable distance, the regulation obtainable with direct current was very unsatisfactory, and that polyphase current was far more suitable. **A. M. Taylor** considered that in cases in which current might eventually be supplied from some large power scheme, polyphase motors should be put in, as it was doubtful whether in such power schemes it would pay to put in rotary converters. Other speakers advocated direct current, and some pointed out that the difficulty of speed regulation, in connection with polyphase motors, was generally in practice of very minor importance. W. H. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1810. *Grimsby Electricity Works.* (Electrician, 47. pp. 127–131, May 17, 1901.)—This station has been designed by Kennedy on the direct-current system. The boiler-house contains three Lancashire boilers 28 feet by 8 feet; each boiler has a steam drum 2 feet in diameter and 8 feet long. The economiser contains 144 tubes. The chimney is 180 feet high, tapering from 13 feet to 11 feet internal bore, with a fire-brick lining carried up to 25 feet. The main steam ring consists of 8-inch pipes; the branch pipes to the engines are in duplicate, one pair of pipes serving two engines. There are at present three steam dynamos, running at

550 r.p.m., having each an output of about 90 kw., and also two small balancers driven by steam. The station will eventually supply the local tramways with power, and for this purpose the machines can be run as shunt machines on the lighting load, or as compound machines on a traction load, the pressure in the latter case being from 500 to 550 volts, and in the former case from 460 to 520 volts. At present two feeders have been laid, one 0·75 square inch, the others 0·35 square inch, in sectional area, the middle wire feeder being 0·1 square inch. In series with the earth current recorder on the lighting board between the middle wire and the earth plate is placed an automatic switch. This switch opens when more than 10 amperes pass, and at the same time throws in a resistance of about 25 ohms between the middle wire and earth, and in parallel with this resistance is a lamp or bell. By this means, even if a dead earth occurs on one side of the network, no serious rise will take place in the pressure on the other side. There is a battery of Tudor cells to take the day lighting load, giving an output of 60 amperes for five hours; the boosters are controlled by Kennedy's usual switching arrangements. There are 78 arc lamps, arranged to run ten in series across a pressure of 460 volts. The article contains a drawing showing a plan and sections of the generating station. The Tramway Company will be supplied at the rate of 1½d. per unit for the first 360,000 units per year, 1⅜d. for the next 100,000 units, and 1¼d. afterwards. W. H. S.

1811. *Ilford Electricity Works.* (Elect. Engin. 27. pp. 735-744, May 24, 1901.)—The supply to consumers is on the three-wire continuous-current system, with 460 volts between the outers. There are three Babcock boilers, each with a heating surface of 2,197 square feet, worked in conjunction with an economiser of 196 tubes. The chimney is 185 feet high, and has an internal diameter of 8 feet at the top. There are three steam dynamos by Willans & Robinson and the General Electric Co., the two larger having an output of 200 kw., and the smaller of 100 kw. They are run as shunt or compound machines, according as they are used for lighting or traction. The switchboard is by Kelvin & White, and is described in considerable detail. There are 270 cells by the E.P.S. Co., discharging at the rate of 200 amperes for three hours. The cables are armoured and laid direct in the ground. The article contains a large number of drawings, including section and plan of the generating station, drawings of different sections of the boiler-house, the connections on the main switchboard, details of the transmission gear for working the accumulator regulating switches, details of the feeder pillars, a drawing of the arc-lamp and tramway poles, and of the base of the tramway poles with switch-gear for arc lamps, and the connections to the arc and incandescent lamps. W. H. S.

1812. *Rotherham Electricity Works.* (Elect. Engin. 27. pp. 770–774, May 31, 1901.)—This station, which was designed by Kennedy, supplies continuous current. It contains two Lancashire boilers, 28 feet by 8 feet, working at 160 lbs. pressure. The engine-room plant consists of two 90-kw. dynamos, two steam-driven balancers, and two motor-driven boosters. The larger dynamos have a compound winding for tramway purposes, and a regulator is placed in the circuit of the series-winding, so that when the two larger machines are worked in parallel, the compounding effect of the series-winding may be altered without affecting the equal division of the current between the dynamos. This is effected by a switch which, in proportion as current is shunted from the series-winding, adds an equivalent resistance in series, thus

keeping the resistance between the equalising bar and the negative bar the same as before. The station also contains 256 cells by the E.P.S. Co., discharging at the rate of 50 amperes for five hours. The article contains drawings showing plan and sections of the station buildings. W. H. S.

1813. *Tynemouth Electricity Works.* (Elect. Engin. 27. pp. 806–812, June 7, 1901.)—This station supplies continuous current. It contains three Lancashire boilers, 30 feet by 8 ft. 6 in., the steam being superheated by Musgrave superheaters. The chimney is 150 feet high and 8 feet in diameter, being intended to serve also for a proposed destructor installation. The feed-pumps are electrically driven, the speed being controlled on the series-parallel system, so as to vary from full to one-quarter of full speed. The engine-room contains three 180-kw. sets, giving their outputs at from 445 to 550 volts, according as the power is required for lighting or traction purposes. A further 520-kw. set has been ordered. There is also a battery of 252 cells, giving 60 amperes for 10 hours. Diagrams are given showing the connections on the lighting and traction switchboards. W. H. S.

1814. *Madrid Electricity Works.* **H. Baswitz.** (Elektrotechn. Zeitschr. 22. pp. 425–429, May 23, 1901.)—The station described belongs to the Electricity Supply Co. for Spain, which is the largest of the fifteen different companies operating in Madrid. The station, which is 1½ miles from the centre of the town, has recently been almost entirely reconstructed by the Union Electricity Co. of Berlin. The rubber cables, which had been used, were to a large extent perished, and the arrangement of the machinery was out of date. The new installation is on the monocyclic system. The boilers have remained unchanged, and consist of Babcock boilers, of which eleven have a heating surface of 1,827 square feet, and four have 3,240 square feet. Spanish coal is used, though inferior in heating capacity to English coal, but the latter is too expensive. A reservoir holding about 700,000 gallons has been constructed to provide water during the period of drought, which lasts about six weeks in summer. The old chimney was 115 feet high, and a second has been erected 165 feet high and of 10 ft. 6 in. diameter. The new machines include four monocyclic generators, giving 450 kw. each, at 2,200 volts and 125 r.p.m., with 50 cycles per second. The engines are compound vertical, and were built by Swiderski, of Leipzig, being fitted with jet condensers. The condensing water is cooled by towers, the water falling 23 feet, and being circulated by centrifugal pumps driven by induction motors. The connections on the switchboard are clearly shown by a diagram, as also the arrangement of switches, instruments, cut-outs, &c. The 20-ton travelling crane has a span of 56 feet. The distributing system was in a state of great confusion, largely owing to the fact that in Madrid the gas, water, and electric light companies are allowed to remove their pipes without being subject to any control, and without consulting one another. It is hoped that this state of affairs is at an end. Lead-covered armoured cables, insulated with impregnated yarn and paper, are now used. There are two main sub-stations, 38 kiosks equipped with transformers, and two underground stations. In all, these contain 70 oil-transformers of 30-kw. capacity, distributing on the three-wire system, with a pressure of 200 volts between the outers. Most of the transformers are switched off at midnight. W. H. S.

1815. *Electrical Development at Manchester, N.H.* (Elect. World and Engineer, 37. pp. 857–861, May 25, 1901.)—The amalgamation of local

electrical supply companies has brought about a novel example in electrical distribution. At a substation at Manchester, N.H., energy is received from five generating stations and distributed to four towns. Three of the stations are run by water power, one has both water and steam, and one has only steam. The most distant is *Garvins Falls*, 14 miles from the substation. The plant here consists of four General Electric generators direct connected to the shafts of the turbines. Each has a capacity of 650 kw. three-phase, 60-cycle, at 10,000 volts. At *Hooksett* there are two generators of the same make for 300 kw. three-phase, at 1,000 volts. A part of the energy is distributed locally at 1,000 volts, and the remainder is stepped up to 10,000 volts, and is transmitted to Manchester, 10 miles away. At *Gregg's Falls* the generation is at 10,000 volts, three-phase, by a single General Electric 1,200-kw. generator. This supplies two towns at 2,000 volts, but the bulk of the power is transmitted to the Manchester substation, a distance of 6 miles. *Kelley's Falls* station is three miles from the substation. It has four generators—one 300 kw. three-phase 2,000 volts, by the General Electric Co., and three other two-phase machines. The transmitting pressure is at 6,600 volts for the three-mile line. At *Brook Street* station in Manchester the plant is of a different kind. Three 600-volt generators for railway work of capacities 500, 300, and 200 kw., deliver their energy directly from the station switchboard. This also applies to the arc lighters for 487 lamps in the Manchester streets. There are also four three-phase generators with a total capacity of 1,250 kw., which supply at 2,000 volts to the substation, 150 yards away. Underneath the main floor of the substation is an air-tight basement, which is intended to serve as an air-pressure chamber. Two blowers, each driven by a three-phase motor, maintain the air in the basement at a higher pressure than outside. Over openings in the main floor the necessary transformers are placed, and there is a rapid flow of air through them. The switchboard is of somewhat special design ; it distributes at 2,000 volts and 60 cycles. The system requires 33 miles of overhead lines. Double petticoat *glass* insulators are used. Where the lines pass through the city on their way to the substation they are carried over all other wires.

The collection of energy from these distant sources is making Manchester independent of coal supply. Many hundreds of electrical horse-power are being supplied to manufacturers at a price which has led them to discard steam engines. W. W. H. G.

1816. *Electrical Plant of the Curtis Publishing Company.* **J. S. Griggs, Jr.** (Elect. Rev. N.Y. 38. pp. 417-421, April 6, 1901.)—The new shops of this company in Philadelphia are electrically driven throughout. The powers required by the different machines were very carefully determined by experiments on similar electrically driven presses. The plant, which is a "three-unit" one, any two units being easily capable of taking the maximum load, comprises three 250-h.p. Babcock boilers working at 160 lbs. per square inch with a Green's economiser, and induced draught, which was used owing to the stack being only 30 in. × 40 in. × 90 ft. high. The economiser is found to reduce the coal bill by 8 per cent., and so cools the gases that the power required to run the fans is less than half that required when the economiser is cut out. The induced draught is furnished by one of two 120-inch "American" fans, driven by an 8-h.p. direct-connected motor at any speed from 100 to 275 r.p.m. Normally the fan takes only 3 h.p and the economiser scrapers, which are only run a few minutes a day, take ½-h.p. To increase the economy of working, while utilising exhaust steam for heating,

the Webster vacuum return system was installed, whereby the exhaust gauge never exceeds ½ lb. per square inch. The exhaust steam first passes through a 600-h.p. Cookson heater, and then goes to the buildings, whence the condensation is returned to the feed water heater at about 170°. The make-up feed is automatically supplied from the city mains through a float valve in the heater, and is raised to about 210°, mixed with the returns and fed into the boilers by one of two Gould motor-driven pumps, capable of pumping 40 gallons per minute, and arranged for any desired speed down to one-third of the maximum.

Each press is controlled by two rotary controllers of the tramway pattern. One is a series resistance, used in starting only; the other determines the running speed, and is either wholly a shunt resistance, or partly shunt and partly series, according to the range of speed required. Shunt regulation alone gives a range in the rotary presses from 65 to 35 impressions per minute, and from 14 to 20 on the top-cylinder presses. During one month there were delivered to the switchboard 83,400 kw.-hours. at a cost (including taxes, insuring, interest, depreciation, repairs, &c.) of 1·49 cents. per kw.-hour, which is a quarter of the lowest price obtainable from the Supply Company. E. H. C.-H.

1817. *Combined Electric Lighting and Steam Heating Plant.* **W. N. Zurfluh.** (Amer. Electn. 13. pp. 201–207, May, 1901.)—This plant includes two 400-h.p. boilers, with underfeed mechanical stokers, and 3 six-pole dynamos, of 100 kw. each, compound wound for 120–125 volts at 225 revolutions per minute, driven direct by simple horizontal engines having cylinders 14¼-inch diameter and 16-inch stroke. The lighting supply is carried out on the two-wire system. Heating is done both by exhaust steam (entailing a back pressure of 2 to 5 lbs. per square inch, according to the season), and by steam at boiler pressure (120 lbs. per square inch). A. H. A.

1818. *High Pressure Transmission in New York City.* **C. W. Rice.** (Elect. World and Engineer, 37. pp. 899–900, May 25, 1901. Paper read before the National Electric Light Association.)—The author describes in outline the scheme which is being carried out for the electricity supply of New York. Four power-stations are being erected, which are to contain three-phase generators working at 6,600 volts, 25 cycles per second (one station will work at 11,000 volts). The largest station is designed for 125,000-h.p. in 16 sets. Power is to be distributed through cables, some insulated with rubber, others with paper, to substations, where transformers and six-phase rotary converters transform it to direct current, feeding the Edison three-wire system at 135 volts each side. A. H. A.

1819. *The Metropolitan Railway of Paris.* **A. Dumas.** (Génie Civil, 38. pp. 277–293, March 2, 1901.)—On this line there are eighteen stations, at an average distance of 625 metres. The time occupied in stops has now been reduced to 10–15 seconds; acceleration occupies 10 seconds, and braking 15 seconds. This results in an effective speed of 21 km. per hour, with a maximum of 30 km. per hour. In the daytime, trains are run with three minutes headway. The number of passengers per km. per annum is now more than 4 millions, as against 3 millions per km. per annum on the London Metropolitan, 2·8 millions on the Berlin Metropolitan, and 3·15 millions on the Manhattan Elevated. The Central London Railway, 10·5 km. long, carried 14·5 million passengers between July 30 and December 31, 1900. At Paris

the tickets are printed at each station by a motor-driven apparatus, which also counts them ; it turns out 240 tickets a minute. No change is given at the booking-office, but the newsvendor is bound to supply it. Automatic signalling is employed, on the Hall block system. Pedals, depressed by the wheels, open switches in relay circuits controlling the circuits of electro-magnets at the signals, which cover the signal light with a white or red glass. Diagrams of connections are given in the paper. When a train passes over a pedal it puts the signal at danger, leaving the previous one also at danger, but restoring the third signal behind it to "line clear."

The generating station at Bercy contains four 1,500-kw. generators with transformers and auxiliaries. The 18 boilers are of the semi-tubular type, mechanically fed with coal which is first conveyed 95 m. underground from the barges on an endless moving platform, then raised 24·5 m., weighed automatically in one-ton lots, fed into 60-litre chain-drawn cars, and thence into the hoppers. The apparatus will handle 60 tons per hour, with an expenditure of 20 h.p.-hours, the distance being 200 m., and the difference of level 10 m.

Three of the 1,500-kw. machines supply three-phase current at 5,000 volts and 25 periods. The rotating magnets are of the radial pole type, and take about 1·5 per cent. of the output at full load. The fourth unit is a direct-current 600-volt machine, shunt-wound and guaranteed to give constant voltage within 5 per cent. whatever the load. The stationary magnet has 20 poles ; the armature is slotted and bar-wound. The 65-kw. exciters at 140 volts are driven by 600-volt shunt-wound motors. There are also 200-kw. boosters, capable of raising or lowering the voltage to the extent of 25 volts. These are driven by shunt-wound motors, the booster-generator fields being series-wound. The boosters are intended to act as regulators, making the battery (of 260 Tudor cells, with a capacity of 1,600 ampere-hours at a 1-hour rate) operate in the most efficient way as a "flywheel." Static transformers reduce the 5,000 volts to 430 volts, and rotaries convert this into direct-current at 600 volts. The transformers are air-cooled, weigh 6 tons each, and have their primaries connected in triangle, the secondaries being independent.

At the Place de l'Étoile is a substation containing four 750-kw. transformers and rotaries of the same type as at Bercy ; also a battery giving 1,800 ampere-hours at a 1-hour rate. [See further Abstract No. 2505 (1900).] E. H. C.-H.

1820. *Lisbon Tramway System.* **F. A. Wardlaw.** (Street Rly. Journ. 17. pp. 208–219, March, 1901.)—The tramways in Lisbon are owned by an English company, which at present operates 44 miles of track with about 330 cars and buses, and 1,200 mules : 400,000 passengers are carried per month, with fares from 1d. to 4½d. The gross earnings for 1898 showed a loss of £4,000. Drivers and conductors are paid about 2s. a day. When converting to electric traction, the gauge was altered from 4 ft. 8½ in. to 90 cm. in order to prevent rival buses from taking advantage of the rails. A 91-lb. 7-inch girder rail was used, spiked to ties and cast-welded by the Falk process. Cross bonds were used every 90 feet and between tracks every 300 feet. Owing to the large range of temperatures between day and night, much trouble was experienced with buckled rails, but finally a satisfactory arrangement of clamps was devised. The average conductivity of joints is over 100 per cent. of solid rail. A power station 128 feet by 180 feet is being built for 3,000 kw. There will be six tandem, compound, condensing engines 19 in. and 40 in. by 42 in. stroke, driving G.E. 500-kw. generators at 110 r.p.m. The Babcock boilers will be arranged for superheating 100° F., but it is

doubtful if a satisfactory lubricant can be found. Underfeed stokers will be used with bituminous coal. Natural draught will be supplemented by blowers when necessary. Three series-wound return-current boosters and one feeder booster will be coupled in pairs at the ends of two constant speed 500-volt motors. A battery of 260 Tudor cells (1,440 ampere-hours at 480 amperes) will be placed in the basement of the power-house to act as an equaliser and to take night load. Its charge and discharge will be controlled by a compensating dynamo coupled to a 150-h.p. constant speed motor; this machine will be essentially a differentially wound dynamo, having its series field in series with the negative bus-bar between the generators and the feeder circuits, its shunt field across the bus-bars, and its armature in series with the accumulator and the line. It is so wound that, running as an ordinary shunt dynamo, it has a range of from 50 volts to 180 volts, and 1,000 amperes. When running as a differential machine with a current of 3,000 amperes passing through the series field, there is an electrical balance between the series and shunt fields, resulting in zero potential. Should the current in the series field rise to 4,500 amperes, it overcomes the shunt, and a potential of 75 volts in a direction tending to discharge the battery is produced at the armature terminals. If, however, the series field current should fall to 1,500 amperes, the shunt will overcome the series field, and a potential of 75 volts in a direction tending to charge the battery will be produced. This machine will also be provided with a six-point switch shunting the series field, to admit of adjusting the point where the shunt field overcomes the series, by this means keeping the engines always working at their most economical load.

E. H. C.-H.

1821. *Newcastle-on-Tyne Electric Power Works.* (Electrician, 47. pp. 319–327, June 21; 359–364, June 28; and 397–400, July 5, 1901.)—A station has been erected by the Newcastle-on-Tyne Electric Supply Co., for the purpose of supplying further power to their already existing station at Pandon Dene, and for supplying power in bulk to the Walker and Wallsend Gas Co., who undertake its distribution to manufacturers in the districts round Wallsend, for which they have obtained a Provisional Order. The station at Neptune Bank is first described. The Walker Gas Co. originally intended to build for themselves a station on this site; but the Newcastle Supply Co. took over the site from them, on the understanding that they were to supply the original owners with power in bulk in consideration of the transfer. The station was originally designed for supplying three-phase currents at 5,500 volts with a periodicity of 40; but when the station was taken over by the Newcastle Co., it was proposed to increase the pressure in view of the extended area to be supplied. It was, however, found that the saving in copper would be almost counterbalanced by the increased cost of insulation required by the Board of Trade, and the work was therefore carried out on the original lines. The present site at Neptune Bank will only allow of moderate extensions, and a riverside site of 15 acres' extent has therefore been purchased with a view to contingencies. The present station is situated close to a branch of the North-Eastern Railway, and at present contains eight Babcock boilers, each having a heating surface of 4,020 square feet, and superheating the steam through about 100° F. The steam main consists of a single pipe, 7 inches in diameter; there is, however, in addition a smaller steam-pipe from which the feed pumps and smaller engines are supplied. The steam-pipes are of solid drawn steel tube, both tees and valves having cast-steel bodies. All tees of 5 inches and over are made by riveting a branch pipe

directly to the main. The chimney is 130 feet high, and is made of riveted steel, lined with firebrick. The economiser contains 280 tubes. The boiler-house and engine-room are each 160 feet long, and 52 feet wide. The floor of the engine-room is 8 feet above the level of the boiler-house floor, 32 ft. 6 in. below the 25-ton crane, and 10 feet below the switchboard gallery. The machinery includes four 700-kw. sets, driven by triple expansion marine engines, giving a three-phase output at 5,500 volts, with a frequency of 40 at 100 r.p.m.; one 1,500-kw. Parsons turbo-alternator; two Belliss engines, each driving two 100-kw. 240 volt continuous current generators; one 50-kw. 240 volt continuous-current generator; and one 150-kw. synchronous motor-generator, transforming to 240 volts continuous current. The larger units are run in conjunction with Wheeler surface condensers, the circulating water being cooled by means of a pond provided with Koerting spray nozzles; by this means 325,000 lbs. of circulating water can be cooled per hour. The station is 350 yards from the river, and 60 feet above its level; it was not, therefore, considered possible to use river water for the condensers. The motor-generator set is designed either for receiving alternating three-phase currents, and delivering continuous current, or *vice versâ;* and all continuous-current machines have both shunt and series windings on the magnets. All the auxiliary machinery is motor-driven. Power is distributed and supplied to consumers on a variety of systems. The substations in the Newcastle area will be supplied with high tension current through three-core cables, each core having a sectional area of 0·25 square inches. These cables are to be laid on the drawing-in system, the conduit having nine ways, each 4 inches in diameter; they will be armoured with steel, in accordance with the regulations of the Board of Trade with respect to alternating high-pressure current. Distribution from the substations will be effected on the three-wire continuous-current system. The Manors substation, for instance, contains two 500-kw. synchronous motor-generators, one 75-kw. asynchronous balancing and starting set, one 25-kw. continuous-current balancer, and a 7½-ton travelling crane; drawings are given, showing the general arrangement of plant in this substation. The Walker and Wallsend Gas Co. also receive power in bulk through three-core cables, each core having a sectional area of 0·15 square inch. The high-tension cables are insulated with bitumenised paper, the thickness of insulation between any conductor and earth being as great as that between any two conductors. The low-tension cables in the Gas Co.'s area are insulated with vulcanised bitumen, the mains being arranged on the three-wire system, and consisting for the greater part of 0·5, 0·25, and 0·5 square inch single conductors. This area contains some very large consumers, for whom special substations on their own premises have been constructed. Some of these are described at length in the articles under consideration. At Armstrong's, the substation contains seven 50-kw. transformers, each intended to receive single-phase current. They transform from 5,500 volts to 440, and are connected up in mesh. The motors used are of the induction type. At the North-Eastern Marine Engineering Co.'s works, the substation contains two 150-kw. synchronous motor-generators, receiving current at 5,500 volts, and generating continuous current at 250 volts. This substation contains a 7½-ton travelling crane. At Wigham, Richardson & Co.'s works, both continuous and alternating currents are distributed, and this station contains a 75-kw. asynchronous motor-generator. At the Northumberland Shipbuilding Co.'s Works, there is also a similar asynchronous motor-generator, and there are also four single-phase 75-kw. transformers

ransforming from 5,500 to 440 volts. The motors here used are all f the induction type. The work to which these motors are applied in he different works is shown by means of various illustrations, and ncludes heavy work of all kinds. The article also contains several rawings, showing plan and cross-section of the main station and sub-tations. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1822. *Polyphase Generators and Electric Traction.* **H. M. Hobart.** (Elect. Rev. 48. pp. 872–873, May 24, 1901.)—The author considers that practically all difficulties in the operation of rotary converters are due to the want of a sufficiently uniform angular velocity in the prime movers. With high-speed engines this lack of uniformity can be practically overcome without the provision of an excessively large flywheel, supposing the phase deviation allowable to be 2·5°, and the periodicity to be 25 cycles per second. But with slow-speed engines under the same conditions the flywheel becomes of enormous size, and the usual plan is to endeavour to prevent hunting by the addition of damping coils, or other devices. For slow-speed plant the author would recommend the use of a periodicity of, say, $8\frac{1}{3}$ cycles, which would decrease the number of poles on the main generators and so indirectly assist the engines ; but with this low periodicity, step-down transformers become very expensive. Under these conditions rotary converters should be abandoned, and synchronous motor generators substituted for them. The decreased efficiency of this arrangement as well as its greater cost will be to some extent counter-balanced by the decreased energy required to be expended in devices to prevent hunting, and by the simplification of the switchboard apparatus, as well as by other incidental modifications which would result in the employment of less skilled attendants in the substations. It may, however, still be advantageous to use rotary converters in connection with plants where the generators are direct connected to high-speed engines. W. H. S.

1823. *Polyphase Substation Plant.* **A. C. Eborall.** (Elect. Rev. 48. pp. 963–965, June 7 ; and 1009–1010, June 14, 1901.)—The author deals with the questions raised by Hobart. [See preceding Abstract.] He commences by giving a general outline of a specification for plant for a tramway scheme of not less than 6,000 h.p. He then proceeds to deal with Hobart's assertion that in order to prevent hunting of rotaries worked in connection with slow-speed generators, the flywheel effect in the generators must be very great, and considers that when this is the case it is due to defective design of the engines. To illustrate his point he quotes the case of a 5,000-h.p. engine running at 80 r.p.m., for which inquiries were made, the cyclic irregularity not to exceed 0·2 per cent. up or down. One English firm stipulated for 3,000 foot-tons as the flywheel effect ; another required 8,000 foot-tons ; while a Continental firm guaranteed a cyclic irregularity of 0·15 per cent. with a flywheel effect of 6,000 foot-tons, the engine offered having a lower guaranteed steam consumption than the others. It was indeed more expensive in itself, but with the added cost of heavier flywheel, the others came to about the same amount. The rest of the article is occupied with a discussion of the question of rotaries *v.* synchronous motor-generators. [See also Abstract No. 1802 (1901).] W. H. S.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

1824. *Uninsulated Returns on Tramway Systems.* **J. H. Rider.** (Electrician 47. pp. 340–341, June 21, 1901. Paper read before the Incorporated Municipal Electrical Association, June, 19, 1901.)—The author discusses some points connected with the Board of Trade Regulations. These regulations provide for two separate earth connections to the negative terminal of the generator. One of these earth connections may be made by means of a water-pipe. At Plymouth, the shortest return feeder is 760 yards long, and the resistance between the rails and the earth connection, which is a water-pipe, was found to be about 0·5 ohm. It was found that 25 per cent. of the return current came back through the earth. The author considers that the regulations require revision, seeing that the obvious thing should be to make the resistance of the earth path as large as possible. This is simply done by removing the earth connection from the negative bus-bar. The author therefore holds that where the return conductor consists partly of uninsulated rails and partly of insulated cable, the earth connection should be made at the point where the insulated cable joins the rail, and not at the negative bus-bar. With more than one return feeder, negative boosters could be used to keep the points of earth connection at the rails at about the same potential. W. H. S.

1825. *Energy Consumed by Tramcars.* **E. Volkers.** (Elektrotechn. Zeitschr. 22. pp. 480–483, June 13, 1901.)—The author has conducted a series of experiments with a view to determining the amount of energy consumed by a tramcar under given conditions. The expenditure of energy may be considered as overcoming (1) friction, (2) wind pressure, (3) the force of gravity, in so far as there may be inclines on the road, and (4) the losses incurred by braking. The frictional losses were determined by running the car over a level stretch at very slow speeds, the current being switched off when a speed of 1 or 2 m. per second was reached; the rate at which the speed decreased was then noted. Under these conditions the resistance due to wind pressure was considered negligible. The resistance due to wind pressure was similarly calculated by running the car to and fro at different speeds in calm weather. The speed was determined by means of a Morse recorder, which was worked in connection with a contact-breaking device fitted on one of the wheels of the car. The frictional losses are very greatly increased if one wheel has a very slightly greater diameter than the other; moreover, the brake, if constructed so as to grip on the surface of the wheel, may on a dirty track cause frictional losses, even during the time when the car is supposed to be running freely. The frictional resistance of a certain car was found to be equivalent to 5 kg. per ton before leaving the sheds, but on returning after covering 20 kilometres on a fairly clean but wet track, the losses were found to have increased to 7·8 kg. per ton. The author gives figures showing the values of the resistance due to friction on various kinds of track. For that part of the weight which falls on the driving wheels, the resistance varies from 2·8 to 6·8 kg. per ton, according as the track is clean or dirty; for that portion of the weight which falls on the other axles, and for trailers, the figure varies from 1 to 5 kg. per ton. The wind pressure is difficult to calculate; the author uses the formula $P = 0{\cdot}1225Fv^2$, where P is the total pressure in kg., F is the perpendicular surface exposed in sq. m. (taken to be 7 for ordinary cars, and 2·5 for trailers), and v is the wind-velocity in metres per second. The main point is to determine the mean apparent velocity of the wind; the author gives figures for different cases. The work done against gravity is easily calculated in any case, but no allowance can be

made for runs downhill, seeing that no energy is returned to the line. The losses due to braking can be reckoned by experimentally observing the speed at which the car would pass the stopping-place, supposing the brake had not been applied. These losses are often very serious, and depend to some extent on the skill of the driver. The overall efficiency of the motors and their gearing must also be ascertained, and it is necessary to take account of the fact that, at starting and during the time of getting up speed, the efficiency is very low. The author has found a mean overall efficiency of 60 per cent. with 4 stops per km., and a mean car-velocity of 12 km. per hour, the consumption of energy being noted by a Morse recorder placed in circuit with a Thomson meter and a contact-breaker fixed on a car-wheel, in addition to the speed recorder mentioned above. The article concludes with some numerical examples. It is pointed out that in practice much depends on the skill of the driver. At Copenhagen the cars, weighing 7 tons empty, take 400 watt-hours per car-kilometre, including 4 per cent. loss in feeders and the current used in lighting the cars, the measurements being made in the power-house. As the result of a competition, it was found that some drivers used only 255 watt-hours, while others used 350, the measurements in the competition being made on the car itself, and excluding the lighting current. W. H. S.

1826. *Rail-bonds.* **A. B. Herrick.** (Street Rly. Rev. 11. pp. 281–283, May, 1901.)—The contact surfaces should provide for a current-density not exceeding 90 amperes per square inch, and the surfaces should be under great pressure. Amalgamation of copper bonds is advantageous. Bonding should not be done in damp weather. Supplementary wires are far less efficient than the same amount of copper used in the bonds. Methods of practical testing are described, including one for locating faulty bonds by means of a car equipped with suitable apparatus. A. H. A.

1827. *Power Consumption of Cars equipped with Two and Four Motors.* **W. Pestell.** (Street Rly. Journ. 17. pp. 416–418 ; Discussion, pp. 419–421, May, 1901. Paper read before the New England Street Rly. Club, Feb. 28, 1901.)—The tests made by the author on the Lynn and Boston Railroad show that the power used in a four-motor closed car is greater than that used in a similar two-motor car by about 20 per cent. when motors of the same type and size are employed in each car. For open cars the power consumption is increased by 25 per cent., probably because the two extra motors become a greater proportion of the total load in this case. Under similar conditions a higher speed is always obtained with four motors, which accounts for part of the increase in the power used. The remainder must be due to motor losses and friction, the former being reduced to a minimum for the two motors, as they always run heavily loaded. A comparison of two G.E. 57 motors (52 h.p. each) and four G.E. 1,000 motors (37 h.p. each) shows but a very small difference in the power used, which appears to bear out the above assumption. The temperature of the motors in regular service was measured from time to time, and also a record made of the number of stops, time, power consumption, passengers carried, &c. It was found that the rise of temperature for a two-motor car was over 94° C. after running seven hours, but only 60° C. for a four-motor car after running eleven hours. The hottest place in the motor was found to be between the top field and the brush-holder yoke. The temperature was measured accurately to a fraction of a degree by an instrument similar to an ordinary platinum thermometer, except

that iron wire was substituted for platinum in the thermometer coil, and a telephone receiver was used for determining the balance on the Wheatstone bridge.

Results obtained by Tests, February, 1900.

Length.	No.	Wheels.	Motors.	Watt-hours per Car-mile.	Trucks.
25-ft.	97	30 in.	2 G.E. 58	2,253	14-B. 3 Peckham
„	192	„	4 „ „	2,297·5	„ „
„	621	„	4 „ „	3,034	Laconia

Mean increase in power consumption by use of four motors = 24 per cent.

Results obtained on Closed-car Tests, 1899–1900.

25-ft.	169	30 in.	2 G.E. 58	2,573·8	14-B. 3 Peckham
„	97	„	2 „ „	2,247·2	„ „
„	156	„	4 „ „	2,907·1	„ „
„	128	„	4 „ „	3,013·3	„ „
„	97	„	4 „ „	3,036·7	„ „

Mean increase in power consumption by use of four motors = 24 per cent.

Results obtained on Open-car Tests, 1900.

12-bench open	744	30 in.	2 G.E. 67	1,997·6	Laconia.
„ „	738	„	2 „ „	1,828·2	„
„ „	740	„	4 „ „	2,546·8	„
„ „	759	„	4 „ „	2,425·4	„

Increase in power consumption of four-motor cars over two = 30 per cent.

Comparative Test of 25*-ft. Closed Cars. Watts per Car-mile.*

	No. 801. 2 G.E. 1,000	No. 397. 2 G.E. 1,000	No. 801. 4 G.E. 1,000	No. 397. 2 G.E. 57
W. Lynn to Revere St.....	1,993	1,956	1,984	2,017
Revere St. to Vine St.	2,133	2,209	2,120	2,108
Vine St. to Vine St.	2,491	2,740	2,700	2,558
Vine St. to Revere St.	2,235	2,178	2,555	2,356
Revere St. to W. Lynn.....	1,422	1,602	1,934	1,848
W. Lynn to W. Lynn, *viâ* Swampscott.....	2,717	2,311	2,461	2,340
Total.....	12,991	12,996	13,754	13,227
Average ...	2,165	2,166	2,292	2,204
Total number of trips	4	4	7	8
„ „ of passengers	390	490	694	952
Number of passengers per round trip	97	122	99	119

Car No. 397 was equipped with Peckham truck, 4-ft. wheel base, 33-in. wheels. Car No. 801, Bemis truck, 5-ft. wheel base, 30-in. wheels. Car No. 801, when running with two motors, was equipped with one motor on each truck, on axles nearest the centre of car. Car No. 397, when running with two motors, was equipped with one motor on each truck on axles nearest the ends of the car, with motor suspended between axle and end frame of truck.

Curves for three trial runs are given in the paper, and show the kw.-hours per car-mile, temperature of motors, number of passengers, number of stops, and time. These curves show that the power consumed depends much more on the number of stops made than on the speed.

Discussion.—**Pestell** thought it was shown that two motors, even of small size, are more economical in every way except in repairs, the chief objection to their use being their smaller tractive power. He thought that if some method could be devised—increase of copper or better ventilation—of keeping down the rise of temperature in motors, it would be a great advantage to be able to get a greater amount of work for the same dead-weight carried. **Goss** found that cars with four motors gave no trouble on hills which two-motor cars were not able to climb owing to leaves on the track. J. H.

1828. *Power Consumption of Cars equipped with Two and Four Motors.* **H. H. Bigelow.** (Street Rly. Journ. 17. pp. 418–419; Discussion, pp. 419–421, May, 1901. Paper read before the New England Street Rly. Club, Feb. 28, 1901.)—The results of the tests given in this paper are similar to those given in the preceding Abstract. The author considers the four-motor equipment unsuitable for service on the Boston Elevated Railway Company's system, and does not think that the use of four motors will reduce the cost of maintenance. J. H.

1829. *Diameter of Wheels for Automobiles.* **M. Luxenberg.** (Centralblatt für Accumulatoren, 2. pp. 161–164, June 1, 1901.)—A continuation of the discussion of this question. [See Abstracts Nos. 587 and 1386 (1901).] The experiments which were carried out by Morin in 1840 are quoted, and tend to show that the formula proposed by Müller does not hold good under all conditions. W. H. S.

ELECTRIC LAMPS AND LIGHTING.

1830. *Vapour Lamps.* **P. Cooper Hewitt.** (Elect. Rev. N.Y. 38. p. 513–515, April 27, 1901; and Elect. World and Engineer, 37. pp. 679–681, April 27, 1901.)—The paper contains illustrations of different forms of the lamp, which consists of a tube with sealed-in electrodes, one of which is immersed in a liquid, the surface of the liquid thus forming the electrode in the tube. Curves of measurements taken with the lamps are given, showing that the vapour column approximately follows Ohm's law; efficiencies of 0·32 watt per candle were obtained. G. H. B.

1831. *Cheap Method of Reducing Candle-Power of Lamps.* **P. Stern.** (Elektrotechn. Zeitschr. 22. pp. 451–452, May 30, 1901.) Instead of using a resistance for reducing the candle-power—an arrangement which results in poor efficiency in so far as the production of light is concerned—the author uses a two-way switch by means of which an auxiliary lamp may be connected in series with the main lamp. This auxiliary lamp is so chosen as to be fully incandesced when joined in series with the other. The most economical arrangement is obtained when the auxiliary lamp is supplied at half the p.d. of the mains. A. H.

1832. *Incandescent Lamp in Practice.* **F. W. Willcox.** (Elect. World and Engineer, 37. pp. 897–899, May 25, 1901. Abstract of paper read before the National Electric Light Association.)—The author deals generally with the construction and characteristics of American incandescent lamps and emphasises the importance of free renewal by the supply authority; it is

stated that this costs about 0·2d. per kilowatt-hour sold. The whole of the lamps should be regularly removed and tested and the bad ones replaced. A. H. A.

1833. *Electric Stage-Lighting.* **A. Bainville.** (Électricien, 21. pp. 212–216, April 6; 257–263, April 27; and 291–293, May 11, 1901.)—In this paper the Mornat and Langlois system, which is in use at the Opera, is first described. In this arrangement a series of variable resistances is connected up to a rectilinear commutator over which a contact-piece is moved by a motor, so that any predetermined series of variations of light can be reproduced automatically when the motor is started.

The other system is due to the Compagnie Générale d'Éclairage et de Force (a. é. Clémançon) and enables the lighting to be controlled from the stage itself. The resistance wires are wound on horizontally arranged drums dipping into mercury-baths. These drums are rotated slowly by separately excited motors which are themselves controlled by means of a shaft rotated slowly by a motor, and bearing a number of discs to the sides of which pins can be secured in any desired positions. The pins of each disc act on the ends of a rocking arm mounted on the same shaft as the bridge-piece of a mercury reversing-switch which, when in its normal horizontal position, also short-circuits the armature of one of the motors driving the resistance drums. By suitably setting the pins in the several discs any desired cycle of changes in the light can be performed automatically. C. K. F.

REFERENCES.

1834. *Design for Distributing Networks.* **C. A. Gillin.** (Elect. Engin. 26. pp. 764–766; 798–799; and 834–836, 1900.)—Notes on design having regard to—(1) uniformity and variation of pressure; (2) breakdowns; (3) localisation of faults. W. R. C.

1835. *Falk Joint.* **Pédriali.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 524–534; Discussion, pp. 534–536, Feb. 7, 1901.)—A detailed description of the methods used. E. H. C.-H.

1836. *Underground Cables.* **A. Devey.** (Elect. Rev. 48. pp. 605–606, April 5, and p. 645; with Discussion, pp. 645–647, April 12, 1901. Abstract of paper read before the Glasgow Section of the I.E.E., March 13, 1901.)—Some notes on the various systems of laying underground cables. W. H. S.

1837. *Safety Regulations for Overhead Trolley Systems.* **J. Heitzinger.** (Zeitschr. Elektrotechn., Wien, 19. pp. 211–212, April 28, 1901.)—An account of the regulations recently adopted in Vienna regarding the protection of telegraph and telephone wires against accidental contact with an overhead trolley-wire. A. H.

1838. *Working Expenses of Electric Railways.* (Tram. Rly. World, 10. pp. 174–177, April, 1901.)—Statistics, extending in some cases over a series of years, are given relating to British Railways, including the Liverpool Overhead Railway, the City and South London Railway, the Glasgow Subway, and the Central London Railway.

1839. *Electric Cabs in Paris.* **H. E. P. Cottrell.** (Feilden, 4. pp. 513–530, May, 1901.)—An account of the electric cabs which were running recently in Paris. W. R. C.

1840. *Electric Automobiles* v. *Tramcars.* **A. D. Adams.** (Cassier, 19. pp. 443–448, April, 1901.)—The author considers the possibility of running electric automobiles more cheaply than electric tramcars. W. R. C.

1841. *Transmission and Spring Suspension of Electric Automobile Motors.* (Horseless Age, 8. pp. 62–65, April 17, and 109–110, May 1, 1901. From a paper by **R. Conrad** in the Motorwagen.)—A number of different systems are described and illustrated, together with comments on the merits and demerits of each of them and on the general principles involved. E. J. W.

1842. *Sprague Multiple-unit System.* **F. J. Sprague.** (Street Rly. Journ. 17. pp. 371–384, May, 1901.)—A full description of this system with diagrams of wiring and illustration of each piece of apparatus. E. H. C.-H.

1843. *Electricity* versus *Steam for Heavy Railway Service.* **L. D. Tandy.** (Tram. Rly. World, 10. pp. 219–226, May 9, 1901.)—Comparative figures are given concerning six branch lines of a large American Railway Company, showing the calculated costs when electrically worked as against present costs with steam. E. H. C.-H.

1844. *Graphical Treatment of Traction Problems.* **P. Pforr.** (Elektrotechn. Zeitschr. 22. pp. 411–415, May 16, 1901.)—The author traces out the analogy between a loaded beam and an overhead conductor from which current is tapped at various points, and shows how the funicular polygon may be applied to the investigation of problems regarding the fall of potential along an overhead trolley wire. A. H.

1845. *Krizik's Block-Signalling System.* **A. Prasch.** (Zeitschr. Elektrotechn., Wien, 19. pp. 259–261, May 26; and 269–274, June 2, 1901. Paper read before the Elektrotech. Verein, April 3, 1901.)—The apparatus described here is substantially the same as that in Abstract No. 2091 (1900), but a number of diagrams are given showing modified arrangements of the circuits. C. K. F.

1846. *Regulation of a Three-Phase Power Transmission Line.* **F. G. Baum.** (Elect. World and Engineer. 37. pp. 822–824, May 11, 1901.)—In a paper by the author and F. A. C. Perrine [see Abstract No. 2325 (1900)], an analytical investigation was given of the problem of power transmission by means of overhead wires. An equation was found which enabled the voltage at the generator terminals to be calculated for any load and any power-factor. In this paper a graphical interpretation is given of the equation, and it is shown that it is equivalent to a simple diagram which can be usefully employed for predetermining the regulation on any particular transmission line. The diagram is applicable to any alternating current system of transmission. Numerical examples illustrating this method are completely worked out for two separate three-phase systems, one 15 and the other 150 miles long. The diagrams show at a glance what the generator voltage is for various loads on the motors at the far end of the lines. A. R.

1847. *Barnes Electricity Works.* (Elect. Rev. 48. pp. 933–935, May 31, 1901.)—A short description of this station, which supplies current on the continuous-current system. The engine-room contains two 150-kw. dynamos, the boilers supplying superheated steam. W. H. S.

1848. *Chaudiere Falls Power Transmission.* **R. Girouard.** (Elect. World and Engineer, 37. pp. 1009–1011, June 15, 1901.)—This scheme utilises the power developed by a waterfall, 115 feet high, about 9 miles from Quebec.

TELEGRAPHY AND TELEPHONY.

1849. *Alternating Currents in Telegraphy.* **J. Piérart.** (Soc. Belge Élect., Bull. 17. pp. 485–493 ; Discussion, pp. 493–495, 1900.)—This paper treats of Delany's, Crehore and Squier's, and Rowland's systems. In Delany's chemical telegraph the Morse code is employed and the contacts in the transmitter take place through a tape perforated similarly to that of a Wheatstone. One brush operates through the series of holes on one side of the tape, and the other acts similarly on the other side; a positive battery transmits in the first case, and a negative in the second. At the receiving end three iron styles or pens press upon a paper tape which is saturated with cyanide of potassium. The middle style is connected to line, the two outer to earth. A positive current coming from line causes the former to stain the tape, while one coming from earth causes the outer styles to mark. Points are counted on the middle line and the double marks from the outer styles are counted as bars. Hence the usual signals can be composed. A speed of 8,000 words per minute has been obtained in the laboratory, but for 800 kilom. of actual line 1,000 words.

The author gives credit to Crehore and Squier for first utilising a sinusoidal current for telegraphy, and a description is given of the system. [See Abstract 1969 (1900).] Finally the author describes Rowland's system.

E. O. W.

1850. *Röder-Oprendak's Loud-speaking Microtelephone.* **W. Krejsa.** (Zeitschr. Elektrotechn. Wien, 19. pp. 312–313, June 23, 1901. Paper read before the Elektrotechn. Verein, Vienna, April 10, 1901.)—The feature of this arrangement is a special form of induction coil for use in the usual manner, *i.e.*, with the microphone and a battery in a local circuit including the primary of the induction coil. This induction coil consists of an oblong core of laminated iron divided to form two horse-shoes, one of which is fixed and the other is supported in a guide and held with its ends at a short distance away from the fixed horse-shoe by means of a spring. The movable core or armature is provided with an additional coil through which a current is passed from a battery, which polarises the armature, so that its two poles are opposite unlike poles of the fixed horse-shoe. Actual contact of the poles is prevented by inserting a piece of non-magnetisable metal between them. This arrangement causes the variations of current in the primary to be intensified in the secondary and the loudness of the sounds emitted by the receiver to be increased without interfering with the clearness. C. K. F.

1851. *Wireless Telephony.* **E. Wilson** and **C. J. Evans.** (Electrician, 47. p. 46, May 3, 1901.)—The current from a telephone transmitter energises a small electromagnet which is placed with its poles one on either side of an electric arc. In circuit with the arc is a coil 4 feet in diameter, consisting of forty turns of No. 18 S.W.G. cotton-covered copper wire. The receiver may be another such coil with a telephone receiver in circuit, or it may have an arc in circuit instead of the telephone, in which case a rubber tube fitted to the hollow carbon conveys the sounds produced in the receiving arc to a microphone and telephonic receiver. J. E.-M.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1901.

GENERAL PHYSICS.

1852. *Maximum Density of Aqueous Solutions.* **L. C. de Coppet.** (Comptes Rendus, 132. pp. 1218–1220, May 20, 1901.)—This is a study of the molecular lowering of the temperature of maximum density of water produced by the solution of chlorides, bromides, and iodides of potassium, sodium, rubidium, lithium, and ammonium; and of the relations of these lowerings among themselves. In accordance with the law of Despretz, the lowering of the temperature of maximum density is proportional to the quantity of substance dissolved. The molecular lowering is very nearly constant, except in the case of lithium, where the molecular lowering increases with the concentration.

The following table gives the mean molecular lowerings :—

	Chloride.	Bromide.	Iodide.
Rubidium	11·7°	13·2°	15·6°
Potassium	11·6	12·8	15·4
Sodium	13·2	14·5	17
Lithium	6·0	7·0	8·3
Ammonium	7·2	8·7	11·1

The ratio between the lowerings produced by the chloride and the bromide respectively is nearly the same for every metal of the same group. E. E. F.

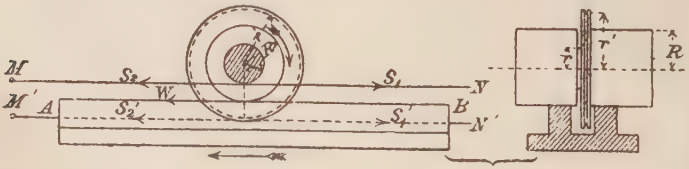
1853. *Density of Ice.* **H. T. Barnes.** (Phys. Rev. 13. pp. 55–59, July, 1901.)—In a paper in the Phys. Rev. in 1899 [Abstract No. 397 (1899)], Professor Nichols found a difference of 2 parts in 1,000 between old and new ice. This paper gives a description of taking the density of ice by weighing it in ice-cold water with suitable precautions, and the author finds that the density of old and new river ice is the same, and may be taken as 0·91661 ± 0·00007, which agrees within 2 parts in 10,000 with that given by Nicholson for natural river ice not newly cut, which is 0·91644, and, to the same order of accuracy, with the measurements of Bunsen. E. C. R.

1854. *Vibrations of Liquid Surfaces of Determinate Shapes.* **C. Chéneveau and G. Cartaud.** (Comptes Rendus, 133. pp. 273-276, July 29, 1901.)—A short paper on the figures of ripples produced on the surface of mercury contained in dishes of different shapes under the influence of vibration. Illustrations are given for the cases of rectangular or square dishes, and of circular dishes. The nature and inclination of the walls have no effect on the form of the ripples. Grains of lycopodium, or light floats, thrown on the vibrating surface, describe closed paths whose number and shape vary with the profile of the dish and the method of vibration. W. C. H.

1855. *Polish.* **Rayleigh.** (Nature, 64. pp. 385–388, Aug. 15, 1901. Paper read before the Royal Institution, March 29.)—A lecture, with experiments, on the nature of the process known as "polishing." With finely ground, as distinguished from polished, glass surfaces, it is possible to obtain such a fineness that a candle is seen reflected at an angle of incidence not exceeding 60°, measured from the perpendicular; but these surfaces are still too coarse for perpendicular specular reflection of the longest visible waves of light, although from experiment it seems certain that they are fine enough to reflect without sensible diffusion the longest waves, such as those found by Rubens to be nearly one hundred times longer than the waves of red light. From these phenomena it might be inferred that grinding and polishing are essentially alike, but the balance of evidence appears to point in the opposite direction. While in grinding the action of the powder is by pitting the surface, breaking out small fragments, in polishing the operation is in all probability a molecular one, no coherent fragments containing a large number of molecules being broken out.

The author has made experiments to find how much material is removed during the polishing of glass. In one case a thickness of about six wave-lengths of mean light was removed during the process; in another case, with very finely ground surfaces, polish was effected during a lowering of the mean surface through two or three wave-lengths. Other experiments dealing with the action of hydrofluoric acid are described. W. C. H.

1856. *Experiment in Dynamics.* **V. v. Niesiolowski-Gawin.** (Ann. d. Physik, 5. 2. pp. 479–482, May 29, 1901.)—The author describes a modification of Kommerell's apparatus for producing a downward motion on an



inclined plane by an upward pull. A roller is mounted on a couple of rails, and provided with two pulleys of radii r and r'. A string is wound round either of the pulleys, and held taut by the hand at N or N'. The rail is displaced along its own length, and the roller goes with or against it in accordance with the pulley used. The rolling surface must not allow of sliding. E. E. F.

1857. *Surface Tension of Oil Films on Water.* **R. H. Weber.** (Ann. d. Physik, 4. 4. pp. 706–721, April, 1901.)—When olive oil is dropped on water, a

m is formed in the middle of which an oil drop persists. The experiments ow that the size of this drop, its angle of contact, and the surface tension the film, vary with the size of the surface. The values of surface tension und varied also with time, and it was concluded that the film consisted of a ird liquid formed from the oil and water, probably by hydrolysis. The rface tension of the film may assume values much smaller than the eoretical one, viz., 5·4 mg./mm. G. E. A.

1858. *Influence of Pressure on the Viscosity of Water.* **L. Hauser.** (Ann. d. hysik, 5. 3. pp. 597–632, June, 1901.)—The influence of pressure up to 500 mospheres in the temperature range of 15°–100° was studied. The capillary be method was employed. The paper contains an elaborate account of the paratus and methods employed. The chief results are as follows :—

(1) Up to 32° increase of pressure diminishes the viscosity.

(2) In this temperature region the effect of pressure diminishes with creasing temperature.

(3) In the neighbourhood of 32° increase of pressure up to 400 atmospheres as no effect on the viscosity-coefficient.

(4) Above 32° the viscosity is increased by an increase of pressure of 400 tmospheres. F. G. D.

1859. *Rotary Comparator.* **J. Pernet.** (Archives Néerlandaises, 5. p. 395–406, 1900.)—The form of transverse comparator which is least subject errors produced by bending is that of Wild, in which the rods to be com- ared are mounted in a frame in a vertical plane and are lifted vertically into ght. This form of comparator fails when the rods are to be immersed in iquids. The author constructs a rotary comparator which admits of exchange ith extreme smoothness and simplicity. A stout cylinder rotates about its wn axis, which is placed vertically. The cylinder carries a table in form of lemniscate, on each of the leaves of which one of the rods is mounted, and upported at $\frac{1}{4}$ and $\frac{3}{4}$ of its length. The author gives full details of con- truction. E. E. F.

1860. *Contact Deformation of Elastic Bodies.* **A. Lafay.** (Annal. Chim. Phys. 23. pp. 241–288, June, 1901.)—This paper contains the full description nd discussion of the author's experiments, concerning which a preliminary ote has already been published [see Abstract No. 4 (1901)]. The deforma- ions of two spheres of steel or of bronze when in contact with one another nder different pressures, and the deformations when a sphere is in contact vith a plane surface, are fully examined, and the results compared with those iven by Hertz's mathematical analysis of the problem. The author finds hat Hertz's formulæ only imperfectly represent the real phenomena. In articular, Hertz's conclusion that the diminution of distance between centres f two bodies under pressure p varies as $p^{\frac{2}{3}}$ is only true where the deformations f the bodies are relatively large. The divergence from theory becomes reater as the deformations become less, and this is all the more singular in hat the theory is based on conditions of small deformation. Friction etween the two deformed bodies appears, on experiment, to be insufficient o account for this singularity. W. C. H.

1861. *Permanent Deformations.* **H. Bouasse.** (Annal. Chim. Phys. 23. p. 198–240, June, 1901.)—A searching criticism of Coulomb's theory (Savants trangers, 1773) as developed by Dugnet (*Limite d'Élasticité et résistance à la*

rupture, 1885) and others. The conclusion is that the theory is in a rudimentary state ; that it does not enable any of the peculiarities of the actual phenomena to be worked out, nor any precise comparison to be made with experiment. In many respects in the form adopted by engineers it contradicts established facts and the principles of Mechanics. An appendix is given as to the action and theory of a draw-plate. A. D.

1862. *Natural Laws.* **H. Pellat.** (Journ. de Physique, 10. pp. 277–279, 1901.)—Referring to the law of dissipation of energy, the author endeavours to trace the consequences of this in past time. Proceeding backwards, energy would be more and more differentiated and entropy would continually decrease. As a result it must follow that if the Universe is finite as regards matter and energy, it has been created, or at least the laws called natural have been modified at an epoch separated from our days by a finite time. J. J. S.

1863. *Hailstorm Artillery.* **W. N. Shaw.** (Nature, 64. pp. 159–161, June 13, 1901.)—The practice of firing off gunpowder to protect vineyards from hail is spreading. According to Pernter, cylindrical mortars are used in Austria ; they are provided with large conical mouthpieces, and are made in three sizes, varying in length between 2 m. and 4 m., and taking charges of from 60 to 250, generally 180 g. of powder. Pernter finds that the vortex rings, discharged from the large mortars, have an initial velocity of 55 m. per sec., and reach a height of 400 m. As the storm-clouds are generally at the 1,000-metre level, the vortex rings would hardly reach the clouds even when discharged from an altitude of 500 m. The experiments thus do not account for the effects observed. H. P.

1864. *Fog Studies on Mount Tamalpais.* **A. G. McAdie.** (Monthly Weather Rev. 29. pp. 61–63, Feb., and 104–106, March, 1901.)—The first paper concerns the loss of the *Rio de Janeiro*, which was wrecked early in the morning of Feb. 22, 1901, while attempting to enter the Golden Gate. The loss is ascribed to the aberration of sound waves in the fog and also to a strong current. The second paper speaks of refraction of sound waves by fog surfaces and of fog dissipation. There is no mention of new experiments. Photographs of cloud surfaces, disturbed by wind, are reproduced. H. B.

1865. *Solar Activity.* **W. J. S. Lockyer.** (Roy. Soc., Proc. 68. pp. 285–300, June 24, 1901.)—From a re-examination of sunspot records from 1833 to the present time, a long period of variation is detected, having a mean value of 35 years. The length of the short period of mean value, about 11 years, oscillates from 9·5 to 12·5 years. From smoothed curves of the climatic variations by Brückner, and magnetic disturbances by Ellis, it appears that a similar periodicity of about 35 years is also connected with these phenomena. C. P. B.

REFERENCE.

1866. *Thermodynamic Theory of Capillarity and Electrocapillarity.* **G. Gouy.** (Journ. de Physique, 10. pp. 245–253, April, 1901.)—Paper largely mathematical, not adapted to abstracting. A. D.

LIGHT.

8 1867. *Molecular Refraction of Chloral Hydrate in Various Solvents.* **M. Rudolphi.** (Zeitschr. Phys. Chem. 37. pp. 426–447, June 18, 1901.)—The author gives the results of a large number of measurements of the density and refractive indices of solutions of choral hydrate in water, alcohol and toluene, made with a view to determine from which of these solutions the molecular refraction of the dissolved substance can be best calculated. All the four expressions giving the molecular refraction in terms of the molecular weight, refractive index and the density give numbers about equally concordant. The values obtained from the aqueous and alcoholic solutions differ less from those calculated from the atomic refractions of the constituent atoms than do those obtained with the liquid chloral hydrate ; the toluene solutions give numbers considerably greater than the others. Although water is a strongly dissociating solvent and far removed in its action from alcohol and toluene, the former of which has a slight dissociating, and the latter a slight associating, action on dissolved compounds, it is found that the values of the refractive power of chloral hydrate in alcohol agree much better with those in water than with the numbers obtained with toluene. Hence the dissociating or associating power of a solvent is no measure of its suitability for use in refractometric investigations ; nor is optical similarity between solvent and dissolved substance, since, although toluene most closely resembles chloral hydrate, the molecular refraction of the latter obtained from measurements on toluene solutions shows the greatest divergence from the value for the solid hydrate. The influence of the solvent on the molecular refraction of a dissolved compound may be very considerable, as it is strongly felt even in 20 per cent. solutions of chlorate hydrate in toluene. T. H. P.

1868. *Optical Constants of Biaxial Crystals by the Refractometer* **A. Cornu.** (Comptes Rendus, 133. pp. 125–131, July 15, 1901.)—The method depends upon the total reflection from the face of the crystal when it is placed in a sufficiently refracting medium ; and the process of finding the six constants (three indices and three directions) is much simplified. The outline of the procedure is as follows : Determine the angles of total reflection in a series of azimuthal planes drawn through the normal to the crystalline face. Four planes will be found which give maximum or minimum values for the angle of total reflection. Determine these values and also the azimuths of these planes referred to any fixed plane through the normal. Repeating the observation for another face of the crystal, it will be found that of the four total angles in the second case three will be the same as three in the first case. Call all these coincident three angles I_x, I_y, I_z respectively, and the fourth for the first face, I. For the orientation of the first face the fourth value at the second face is not required. Let now N be the index of refraction for the external medium, μ_x, μ_y, μ_z, the three indices for the crystal (N must of course be greater than any of these), then the equations—

$$\mu_x = N \sin I_x, \quad \mu_y = N \sin I_y, \quad \mu_z = N \sin I_z,$$

give these indices.

To find the orientation of the face operated upon, let α, β, γ, be the angles

which the principal directions at the point make with the normal to the face, and let OA, OB, OC, be the azimuthal planes through the normal corresponding to the angles I_x, I_y, I_z. Then the following equation and two similar ones give the values of α, β, γ.

$$\cos^2\alpha = -(\cos \mathrm{AOB} \cos \mathrm{COA})/(\cos \mathrm{BOC}).$$

The optical vectors are thus completely found, and these results are very closely verified by experiments with the Abbe refractometer upon various crystals, especially the clinorhombic crystals of tartaric acid.

The fourth plane of incidence referred to above as giving an angle of total reflection I, leads to a fourth index μ peculiar to that face. It is given by

$$\mu = \mathrm{N} \sin \mathrm{I},$$

and is intermediate between μ_x and μ_z. It can, however, be distinguished from μ_y by the relation—

$$\mu^2 = \mu_x^2\cos^2\alpha + \mu_y^2\cos^2\beta + \mu_z^2\cos^2\gamma,$$

as well as by the previous formulæ. This fourth plane of incidence has the peculiarity that it contains the normal to the ellipsoid of elasticity at the point where the latter is cut by the plane. J. W. P.

1869. *Oblique Refraction at a Spherical Surface.* **A. Champigny.** (Soc. Franç. Phys., Bull. 169. pp. 2–3 ; Discussion, p. 3, 1901.)—The known formula for the refraction of an obliquely incident pencil of rays, viz :—

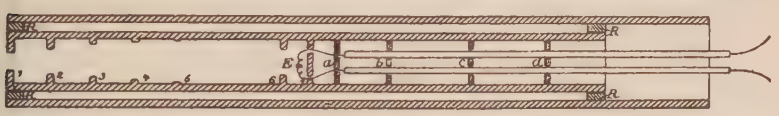
$$\frac{\mathrm{R}\cos i + \mathrm{P}}{\mathrm{R}\cos r + \mathrm{Q}} = \mu \cdot \frac{\mathrm{P}\cos r}{\mathrm{Q}\cos i}$$

is stated. P and Q are the distances of object and image respectively from the refracting surface, R is the radius of the latter, i and r are angles of incidence and refraction, and μ is the index of refraction. A simple proof of this result is given, and its importance in questions of spherical aberration and photographic and microscopic lenses of large aperture is pointed out. In the discussion **A. Cornu** recalled a geometrical construction (given by Young in 1804 and independently by himself in 1864) whereby the pairs of conjugates can be determined. Points on the caustic can thus be found with great ease. J. W. P.

1870. *New Refractometers.* **P. Culmann.** (Soc. Franç. Phys., Bull. 165 pp. 4–5, 1901.)—A short account of some new instruments exhibited by M. Culmann to the Physical Society of France. (1) An instrument devised by Abbe some years ago to show that a luminous source emits more light when it is placed in glass than when surrounded by a medium, like air, of a lower index of refraction. The apparatus consists of two sheets of porcelain separated on the one hand by a block of glass fixed over one of the plates on the other by a layer of air having the same dimensions as the block. Viewed by transmitted light the part of the porcelain which has the glass behind it is brighter than the other. (2) Various forms of the Abbe refractometer, for liquids, are briefly noticed. One of these permits of heating the liquid studied and observing its temperature ; it may be used with white light. (3) An immersion refractometer. (4) An Abbe refractometer which permits of various measurements, such as the determination of the ang

nd the index of the substance. The method of total refraction for the index of refraction may be used with it, and homogeneous light must be employed. A) A refractometer with variable angle for use in the case of liquids of high dex, and for those which attack the glass of the Abbe refractometer. The iquid is caused to take the form of a prism with variable angle. Homo-eneous light must be used. The precision of the instrument is less than hat of the ordinary Abbe refractometer but its scale is more extended. ll these instruments are manufactured by Zeiss of Jena. J. J. S.

1871. *Electrically Heated "Black" Body.* **O. Lummer** and **F. Kurlraum.** (Ann. d. Physik, 5. 4. pp. 829–836, July, 1901. Communicated by the Phys. Tech. Reichsanstalt.)—This paper describes the electrically heated absolutely black body made for the radiation experiments in the Reichsanstalt. The innermost tube, 40 cm. long, is of special porcelain and is fitted with the diaphragms, 1, 2, 3, 4, 5, 6, and 7. The loose diaphragms, *a*, *b*, *c*, *d*, serve to carry the leads to the thermoelectric junction,



. This tube fits into a tube of platinum-foil the thickened ends of which re seen under the porcelain rings R R. The outer tube is of porcelain and covered with asbestos. The platinum tube is heated by an electric current passing along its length, and when the steady state is reached the radiation rom diaphragm 7 through the hole in diaphragm 1 is taken as that of an bsolutely black body. This has been used up to a temperature of 1,520° C., bove which the porcelain begins to conduct. J. B. H.

1872. *A New Pupilometer.* **C. Braileanu.** (Annal. Scientifiques de Univ. de Jassy, 1. pp. 262–264, 1901.)—An account is given of the arrangement devised by the author to measure exactly the dimensions of the pupil or a given intensity of light, in which the usual defects of such instruments re avoided. The two eyes are caused to receive the same quantity of light nd the luminous rays are not stopped by the apparatus used to make the measurements. The arrangement consists of a sheet of glass on which are ngraved two graduated lines meeting at an acute angle. Light from a lamp laced at various distances is caused to reach the eyes after reflection from he plate held in a suitable position. J. J. S.

1873. *Secondary Interferences in Crystalline Sheets.* **Damien.** (Soc. Franç. Phys., Bull. 163. pp. 5–6, 1901.)—An account of the apparatus of Damien which was constructed by Pellin. It consists essentially of two of Biot's hollow vessels superposed (quartz parallel to the axis) which are lit up by transmitted light and placed between a crossed polariser and analyser, an image being formed on a screen by projection. One of the two quartzes can be made to turn in the plane of its base so that its principal section makes an angle, variable at will, with that of the second quartz kept fixed. The first quartz can also be made to slide in the plane of its base so that the centre can be set at a definite variable distance from the centre of the second quartz. The two quartzes are hollowed so as to present in their centre a thickness so

small that when each of them is placed between the polariser and analyser placed at extinction, the well-known rings of Biot, with the black mark at the centre, are caused to appear on the screen. J. J. S.

1874. *Sensitometry of Photographic Plates.* **J. M. Eder.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 1103–1126, 1900.)—This paper contains the results of experiments on the benzine lamp, which the author employed as a secondary standard in the experiments described in his first article [Abstract No. 2157 (1900)]. The Scheiner benzine lamp is described and illustrated. The diameter of the wick-holder is 6 mm., the height of the flame is regulated to 28 mm., and the light shines through a slit 1 mm. high and 15 mm. broad in a screen distant 14 mm. from the centre of the wick. A red glass chimney covers the flame and screen, and has a hole corresponding to the slit. Since benzine is not a well-defined liquid, the Scheiner lamp is not to be recommended as a primary standard. The author tested it as regards constancy, using one sample of benzine; he measured the photo-chemical intensity by means of the Scheiner photometer and Hartmann microphotometer as described in his first paper. The variations in intensity during eight hours' burning were within the limits of error of the observations (about $\frac{1}{4}$ per cent.).

The author next compared the photo-chemical intensities of the benzine and the Hefner amylacetate lamp. The lamps were placed at such distances that their intensities were approximately equal. Measurements were made at different distances and with different plates; the maximum variation in the results was about 1 per cent.; the mean value found for a Scheiner unit was 0·0756 Hefner units. The optical intensity of a Scheiner unit is $0{\cdot}089 \pm 0{\cdot}002$ Hefner units. The Hefner lamp was burnt in all cases without a chimney. The two lights give equal photo-chemical intensity at distances of 1 m. and 3·637 m. respectively.

The author discusses some details of his method of sensitometry, and mentions various precautions necessary to accurate work. A plate showing the Scheiner sensitometer disc in full size is appended. G. H. B.

1875. *Gradation of Photographic Images, with Lights of Different Wavelengths.* **W. de W. Abney.** (Roy. Soc., Proc. 68. pp. 300–321, July 9, 1901.)—The curve of gradation of a photographic plate is conveniently represented by taking the abscissæ as the time of exposure in powers of two, and the ordinates as transparency of deposit. The curve is approximately a straight line for some distance, and at each end tends to become parallel to the scale of abscissæ. The inclination of the straight portion is taken as representing the gradation of the plate. The paper describes a series of experiments undertaken to find how for any plate the gradation varies with the wavelength of monochromatic light producing the image.

Three different methods were employed. Firstly, exposure was made to monochromatic light through a screen of opacity varying in steps, the exposure being varied according to the photographic intensity of the light. Secondly, exposure was made simultaneously to four lights of different wavelengths issuing from the same prism, the time of exposure being varied with successive exposures on separate plates. Thirdly, while exposure was made, as in the last method, to four different colours, the time of exposure was varied by means of a revolving disc with apertures including varying angles.

The results given by the two latter methods are the same, but differ somewhat from those given by the first; this is due to the fact that the density of a photographic image does not depend merely on the product of

intensity of light and time of exposure, but also on the magnitude of the two factors. All three methods, however, lead to the conclusion that the slope of gradation is least for the wave-length which gives maximum photographic effect, and is greatest in the red. This conclusion does not agree with Chapman-Jones's experiments, which point to a gradation slope which diminished with the wave-length; the difference may be explained by his use of orthochromatic plates. The author's first method gives results which apply to camera images taken under ordinary conditions. Calling the slope of gradation given by an amylacetate lamp 1, the slope for red light ($\mu = 0{\cdot}64$) is 1·65—that is, to produce the same slope the successive exposures to red light would have to be shortened in the ratio of 1 : 1·65; the slope for violet light ($\mu = 0{\cdot}42$) is 1·10. The author concludes that this variation in the slope of gradation must constitute a difficulty in three-colour photography.

G. H. B.

1876. *Instrument for Measuring Inclinations.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 21. pp. 205–207, July, 1901.)—The apparent angle between two straight lines may be measured by means of a Dove's reflection prism, *i.e.*, a truncated isosceles prism, in which a ray entering at one face suffers internal reflection at the base, and emerges at the opposite face parallel to its original direction. On placing the eye close to the prism and looking partly along, partly through it the object can be seen directly, side by side with its reflected image. Owing to inversion by reflection, a line and its image will only appear parallel when the line is parallel or perpendicular to the plane of reflection (*i.e.*, when the line appears perpendicular or parallel to the base of the prism). The prism is to be rotated about the line of sight until this is the case, the process being performed separately on each of the two lines in turn, whose inclination is to be measured. The difference of the angles of rotation, which can be read off on a divided circle, is equal to the angle required. The prism must remain fixed during the observations, and this method, therefore, cannot be used at sea. The author describes a hand-instrument (Neigungsmesser) for measuring the inclination of the sounding-wire to the horizon, devised by him for the German Deep Sea Expedition. Two Dove's prisms are placed side by side. One is fixed, the other is to be rotated first to the right and then to the left, until in either case the image of the wire in one prism is seen parallel to the image of the horizon in the other. The mean of the right and left readings being taken, the observation is independent of the zero point. The rays emerging from the Dove's prism pass through an arrangement of reflecting prisms and a third Dove prism. Zeiss was the constructor.

A. E.

1877. *Visual Images formed by Cylindrical and Astigmatic Lenses.* **J. J. van der Plaats.** (Ann. d. Physik, 5. 4. pp. 772–792, July, 1901.)—The article opens with a historical note and a brief preliminary description of the general appearances seen on viewing an object through a cylindrical lens. It is remarked that, though a real image can be thrown on a screen by a convex cylindrical lens, it will not be so sharp as the visual image; for every point of the object is drawn out to a line whose length is greater than the axial length of the lens, and, while the whole line will be visible on the screen, only a fraction of it will be seen in the visual image, since the rays going to form the remainder are cut off by the iris. In the mathematical discussion, the thickness of the lens, and chromatic aberration, are neglected. Starting with cylindrical lenses, the author first takes as object a straight line

in a plane perpendicular to the optic axis, and discusses (1) the magnification for various inclinations to the axis of the cylinder, and (2) the amount and direction of rotation of the image-line when the object-line or lens is rotated. Next taking two straight lines as object, he finds the apparent change of inclination produced by the lens. An arrangement is described for throwing on a screen an imitation of the various appearances. A following section gives geometrical constructions for the formulæ connecting the distances of object and image. Three axes are drawn from a point L at angles of 60°. If LF = focal length, be cut off on the middle axis, and a transversal drawn through F cutting the other two axes at A and B, then LA, LB are the distances of an object and image from the lens. The effect of spherical aberration in curving the image of a straight line is shortly described. Astigmatic lenses are next discussed in a similar manner. A concluding section treats of the action of an ordinary lens held obliquely. A. E.

1878. *Zeeman Effect.* **N. A. Kent.** (Astrophys. Journ. 13. pp. 289–319, June, 1901.)—The author's observations confirm Reese's results [see Abstract No. 2158 (1900)] for certain zinc and cadmium lines, viz., that the separation of the external components for the normal triplet is not proportional to the strength of the magnetic field employed. He has also examined iron and nickel, with similar results for high values of the field strength, though in their case the proportionate falling off in the separation with increase in the field strength appears to be less. Comparing the effect of the magnetic field with the shift of the lines due to pressure, he finds that with iron the divisions of large and small pressure shift are not absolutely the same as those of large and small Zeeman separation. There appears to be no simple law connecting the separation of the various lines in either iron, nickel, or cobalt, but Preston's law is verified for mercury and calcium as well as for zinc, cadmium, and magnesium for the lines given by $n=3$ in Kayser and Runge's formula, and for the lines given by $n=4$ in both the subordinate series of zinc, cadmium, magnesium, and calcium; the ratio of the charge carried to the mass of the particle carrying it varies directly as n for the third set of lines in the second subordinate series, n being either 3 or 4. The results of a study of the anomalous iron lines are given in addition to determinations of the separation for many triplets and quartets. Self-induction in the spark circuit was found of great value for sharpening some of the lines. W. E. T.

1879. *Use of a Scale in Spectroscopes with a Train of Prisms.* **H. Krüss.** (Zeitschr. Instrumentenk. 21. pp. 161–170, June, 1901.)—Simple spectroscopes with a single fixed prism are often provided with a third telescope tube, having a scale at its further end, whose image is brought into the field of view by reflection at the last prism surface. In the case of spectroscopes with a train of prisms set for minimum deviation by automatic adjustment there are difficulties in the way of furnishing this convenience, which have prevented its adoption hitherto. In the author's plan, the scale-tube, which is very short and wide, is fixed above the middle of the apparatus at a higher level than the prisms, with the centre of its objective in the rotation-axis of the telescope. The rays issuing from it are brought to the level of the eyepiece by two reflections, one vertically downwards by a 90° prism, and the other horizontally towards the eye, by a glass plate placed at an angle of 45° in the telescope tube, just behind the cross wires. Between prism and plate is a lens, consisting of two cylinders, for distorting the scale-image lengthwise

and so adjusting its apparent length. The glass plate mentioned above is slightly wedge-shaped, in order that the second image, formed by reflection at the back surface, may be thrown outside the field of view. The lamp for illuminating the scale is fastened to the counterpoise of the telescope. A little automatic contrivance is attached for revolving the scale about its centre, by pressure of a spring, in order to keep it at the same distance from the object glass while the telescope rotates. With the ordinary arrangement of prisms, on moving the telescope, the image of the scale and the spectrum would appear to move in opposite directions. The following method is adopted, which makes them move the same way: the rays, on emerging from the train of prisms, fall upon a right-angled isosceles prism, having its hypothenuse silvered and turned away from the incident rays. These, entering one side at 45°, are refracted to the hypothenuse, whence they are reflected back to the same side, and thence totally reflected to the other side, whence they emerge at right-angles to their original direction.

A. E.

1880. *Photography of Infra-red Spectra of the Alkali Metals.* **H. Lehmann.** (Ann. d. Physik, 5. 3. pp. 633–658, June, 1901.)—Diffraction spectra of metallic vapours were photographed on plates sensitised by Burbank's process. Experiments on the solar spectrum showed that such plates are sensitive for the whole spectrum, from the ultra-violet down to $1000\,\mu\mu$ in the infra-red, except the region between *b* and F, where the addition of uranin or fluorescin will be of assistance. A Rowland plane grating was used. Before entering the slit of the spectroscope, the rays were filtered by Helmholtz's method, being made to pass through two slits and prisms. The blue spectrum of iron of the second order was utilised as a comparison spectrum, being photographed side by side with the first order spectrum of the element examined. The results are discussed in the case of Li, Na, K, Rb, and Cs; while Ca, Sr, and Ba will be dealt with in a future paper. Most of the lines measured fitted into Kayser and Runge's series, and in the case of rubidium, secondary series II was found. Five new rubidium lines, and nine new caesium lines were discovered. Of these nine, five could not be made to fit either known series or a hypothetical secondary series II. Enlarged reproductions of some of the original photographs are given. A. E.

1881. *Distribution of Intensity in Grating Spectrum of the D Lines.* **L. Zehnder.** (Ann. d. Physik, 5. 3. pp. 685–706, June, 1901.)—In the diffraction spectrum of a very intense sodium flame, a sharp dark line may be seen upon each of the bright D lines. These dark lines are presumably due to absorption by the envelope of the flame. The author has found, in observing with a concave grating, that by merely increasing the intensity of the source, and widening the slit, a splitting up of the dark lines takes place which is very similar to the Zeeman effect. He endeavours to explain this theoretically. By adopting certain simplifications, an approximate expression is derived for the intensity at a given point of the image of the slit, showing that the intensity varies from point to point and exhibits maxima and minima symmetrically situated with regard to the centre. The author also suggests the construction of a reflection echelon, not by piling plates, but by cutting steps out of a solid triangular block. Other things being equal, the steps would only need to be about one-quarter the height of those in a transparent echelon.

A. E.

1882. *Photographic Gratings.* **Cotton.** (Soc. Franç. Phys., Bull. 165. pp. 9-11, 1901.)—The author obtains diffraction gratings by photography without employing an object lens. In the ordinary interference apparatus fringes are observed which are only approximately rectilinear and equidistant. If they are illuminated by a parallel beam, the space common to the two beams produced is split up by interference surfaces forming a series of parallel and equidistant planes. A screen or photographic plate with a plane surface is therefore covered by a series of rectilinear and equidistant fringes forming a grating whose spacing can be determined beforehand. If a strictly monochromatic and parallel beam could be produced, and if the surface were perfectly plane, the grating obtained would be faultless. The greatest practical difficulty lies in the lack of parallelism due to the finite dimensions of the source. The author uses a Dufour mercury lamp with tube of fused quartz as a source. The gratings obtained, which contain some 1,200 fringes, or 38 per mm., show two spectra, one on each side of the central plane. They have the peculiarity of not showing any spectra of a higher order, owing to the fact that the amplitude of the vibrations varies as the luminous intensity. E. E. F.

1883. *Gratings made by Photography of Stationary Waves.* **A. Cotton.** (Soc. Franç. Phys., Bull. 169. pp. 4-7, 1901.)—This paper describes the production of gratings by means of photographing the interference fringes obtained when two mirrors are placed nearly parallel. The best results have been obtained by employing a modification of the Daguerrotype method, this being possibly due to the layer being principally sensitive only at the surface. A grating was shown about 5 cm. wide, having about 90 lines to the millimetre. This gave spectra of sufficient purity to separate the components of the yellow line of mercury. Copies are easily obtained by the bichromated gelatine process.

An interesting modification is described where the second reflecting plane mirror is replaced by a spherical one. In this case the interference rings when photographed form zone plates, which show all the phenomena of multiple images, &c. C. P. B.

1884. *Colouring Matters and Chemical Constitution.* **C. Camichel.** (Soc. Franç. Phys., Bull. 165. pp. 6-7, 1901.)—The best method of investigating colours by their characteristic bands of absorption is to define the latter by the point corresponding to the maximum or minimum of transparency according as the band is bright or dark.

This point is invariable ; it does not depend on the thickness of the body, nor on the light falling on the spectroscope. For a solution it is independent of the concentration, if the body follows the law of Beer (proportionality of coefficient of absorption and of concentration), which is a very general one.

To determine the maxima and minima of transparency the method of the rectilinear diameter may be employed. A curve is constructed having wavelengths as abscissæ and coefficients of absorption as ordinates ; this curve is cut by a series of chords parallel to the axis of abscissæ. The conjugate diameter of these chords obtained on joining their mid points cuts the curve very exactly at the point sought.

This method leads to the following results when applied to the indophenols :—

(1) The solutions of indophenols in alcohol, ether, &c., do not follow the law of Kundt.

(2) An ortho substitution in the phenol from which the indophenol is derived produces a considerable displacement of the minimum of transparency, whatever may be the solvent.

(3) A similar meta substitution produces a very slight displacement of the minimum of transparency towards the red or towards the blue.

The method of the rectilinear diameter may be employed for determining the formula of the phenols. J. J. S.

1885. *Röntgen and Secondary Rays, Matter, and Electricity.* **G. Sagnac.** (Annal. Chim. Phys. 23. pp. 145–198, June, 1901.)—Applications of secondary rays to the investigation of purity of metals. As to the influence of the position of a screen on its apparent transparency to Röntgen rays; the screen should be far enough to receive the Röntgen rays which come straight through the laminæ, while the secondary, which start in all directions from the laminæ and weaken with the distance, have become negligible. The influence of the secondary rays is much less important when the receiver is a luminescent screen. The influence of the order of a series of screens upon the apparent transparency of the system is discussed. This is followed by a discussion of the mechanism of discharge by Röntgen rays, taking secondary and tertiary radiations through the field into account: the result depends upon the thickness of the metal and the volume of the air, as well as upon the nature of the metal, the nature and the pressure of the gas, the strength of the electric field, and the form and area of the metallic surface. The differences due to the nature of the metal can be accounted for by the differences in the secondary radiations from the metals, these contributing to make the air more conductive. The bolometric energy of the secondary rays is probably much less than that of the Röntgen rays exciting them: but the activity of the secondary rays may enable Röntgen rays to be detected which in themselves might pass unperceived. The ultra-violet rays studied up to 1900 only dissipated negative charges, and had no effect upon gases, while secondary as well as Röntgen rays affect gases directly. Some peculiarities of the action of Röntgen and secondary rays are readily explained by means of the velocities and *vires vivæ* of the electric charges, liberated by the rays, under the influence of the electric field: and in certain cases these may present analogies to kathodic phenomena. P. Lenard has now [see Abstract No. 1028 (1900)] brought ultra-violet radiations into line with Röntgen and secondary radiations by showing that, at wave-lengths smaller than $0{\cdot}2\,\mu$, ultra-violet rays render gases conductive, and in certain cases discharge both positive and negative charges with practically the same velocity. The conclusion is probable, that secondary rays are Röntgen rays, very slightly penetrative, and possibly intermediate between the Röntgen rays from a soft tube and extreme ultra-violet rays. A part of the secondary radiation from heavy metals does not, however, present this analogy: in their most absorbable portion these radiations comprehend a radiation of negative electricity analogous to that of kathode rays and deviable radium rays; and this portion corresponds to the still more absorbable kathode rays excited by ultra-violet rays (Lenard); another analogy between Röntgen rays and ultra-violet. If d be the mean distance between particles, and λ the wave-length of light, the greater is $2d/\lambda$ the greater will be the amount of scattering and of that absorption which depends upon scattering; hence, mass for mass, gases should be more opaque than the corresponding liquids; and most gases should scatter ultra-violet rays, and do so the more energetically, mass for mass, the lower the pressure. This will explain the scattering of blue light

by the sky. At about $\lambda = 0{\cdot}1\,\mu$ the absorption reaches a maximum, $2d/\kappa$ being then equal to about $\frac{1}{10}$ at atmo. pressure: and thereafter the index of refraction would begin to fall off along with λ, contrary to the law of normal dispersion. At some octaves into the ultra-violet, light would traverse prisms without refraction. If Röntgen rays be irregular successions of disturbances of the type $Ke^{-at}\sin 2\pi t/\theta$, the ordinary "absorption" due to resonance will be greatly reduced after passing through a maximum which is probably not far from that absorption of ultra-violet rays, $\lambda = 0{\cdot}1\,\mu$, by 0·1 mm. of air. Lenard's ultra-violet rays would probably be on the long-wave side of this maximum; Röntgen rays on the other side of it, and the more absorbable they are, then the nearer to Schumann's rays. Secondary rays would then be between ordinary Röntgen rays and Schumann rays: and their production would be in conformity with Stokes's law, whether the original Röntgen radiations be damped vibrations or undamped. A. D.

1886. *Action of Röntgen Rays on Conductors and Insulators.* **J. Semenow.** (Comptes Rendus, 132. pp. 1320–1322, June 3, 1901.)—McLennan has shown that in rarefied gases conductors positively charged are wholly discharged by kathode rays, while those negatively charged can only be discharged less or more completely according to the degree of vacuum. If ionisation were the only cause of discharge by Röntgen rays, the degree of rarefaction should influence both kinds of electrification alike. The present research shows that the ionisation of air by Röntgen rays is not the only cause of the discharge, and that the glass of an electroscope is polarised throughout by the Röntgen rays. The other effective cause of the discharge appears to be either the production of secondary rays, carrying negative charges, or the neutralisation of positive charges by the Röntgen rays themselves. A. D.

1887. *Transparency to Röntgen Rays.* **L. Benoist.** (Soc. Franç. Phys., Bull. 169. pp. 1–2, 1901.)—A discussion of the author's work on the subject [see Abstracts Nos. 1074 and 1273 (1901)]. Villard points out that metals having an atomic weight near to that of silver present anomalous emissive powers for the rays when used as the antikathode, analogous to those observed by the author for their transparency to the same radiation. Sagnac has noticed corresponding anomalies for the activity and degree of transformation of the secondary rays for the same metals. R. S. W.

1888. *Diffraction of Röntgen Rays.* **C. H. Wind.** (Phys. Zeitschr. 2. pp. 292–297; Discussion, pp. 297–298, Feb. 9, 1901. Paper read before the 72nd Naturforscherversammlung at Aachen.)—The author considers his experiments to be the only ones which have hitherto given a positive proof of the diffraction of Röntgen rays. Referring to the spreading of the fringes near the point of a wedge-shaped slit, as shown by photographs in Abstract No. 1897 (1901), the author, after vain attempts to produce Röntgen ray diffraction bands, sought for this spreading near the apex of the wedge-shaped image. The slit was formed from two pieces of platinum $\frac{1}{2}$ mm. thick, and the exposure lasted about 200 hours, several tubes having been used. Several pictures were obtained in which the widening occurs, although feeble. A diagram of the image given shows two bulbous enlargements, one much smaller than the other, the latter being nearer the apex. The size of the slit is microscopic, varying from 14 μ to 2 μ, the wave-lengths being 0·2 $\mu\mu$ and smaller. A

description is given of the method of deducing the wave-length from the pictures by the use of a Fourier series. G. E. A.

1889. *Radio-active Material.* **F. Giesel.** (Chem. News, 83. pp. 122–123, 1901. From the Berichte, No. 19, 1901.)—Doubts are cast on the validity of Hofmann and Strauss's discovery of radio-active lead, on account of the difficulty of separation and detection of radio-active material, and the readiness with which insoluble sulphates, such as those of barium and lead, carry over active material. Giesel has confirmed Walkhoff's observation of skin wounds caused by radium rays, by applying 0·27 gm. of radium barium bromide in a capsule to the arm, when, after two or three weeks and much inflammation, the outer skin peeled off. The rays have a similar action on plant life, and also affect salts, glass, paper, &c. G. E. A.

1890. *Radio-activity of Radium Salts.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 133. pp. 276–279, July 29, 1901.)—The authors have shown in previous papers how, by means of radium salts, radio-active properties can be given temporarily to any body, but more especially to water distilled from solutions of these salts. In this paper they give a theory to account for the experimental facts. We may suppose each atom of radium to act as a continuous and constant source of radio-active energy. This energy, stored in a body by radium, is dissipated in two ways: (1) By radiation (rays charged and not charged with electricity); (2) by conduction, *i.e.*, by gradual transmission to neighbouring bodies by means of liquids and gases (shown as induced radio-activity). The radio-active energy of a body goes on increasing till we come to a point at which the loss by these two means balances the gain, and then we have equilibrium. Except in special conditions, there is no gradual communication of activity through solid bodies. Thus if a solution is kept in a sealed tube, only the loss by radiation can subsist, and the result is a very high radio-activity in the solution. But in an open vessel the solution loses activity by conduction also, and when equilibrium is established the radio-activity of the solution is very weak. In a solid radio-active body it is only a thin superficial layer which produces induced radio-activity, so that the activity of the body does not sensibly diminish; but in solution, the salt divides its activity between itself and the water, and on distillation the water takes away a large part of the activity. W. C. H.

1891. *Phosphorescent Bacilli of the Baltic Sea.* **J. Tarchanoff.** (Comptes Rendus, 133. pp. 246–249, July 22, 1901.)—The cause of the luminosity of these bacilli is here traced to their respirative processes, and is found to vary with the oxygen consumption. The condition appears to be roughly periodic and may last from two weeks to three months. The effect of various physical agencies is investigated. Heat enfeebles the luminosity, and a temperature of 50° C. permanently destroys it. Freezing the liquid leaves the ice luminous for some time, but soon causes a temporary extinction; on reheating, the luminous condition is restored. Electric currents, either from battery or induction coil, localise the luminosity at the negative pole and eventually cause a temporary disappearance. Mechanical shocks and oscillations cause initial increase but eventual extinction. The effects of various organic and inorganic reagents is then stated, and the production of "luminous frogs" by injection of the liquid is described. J. W. P.

REFERENCES.

1892. *Interferometer.* **C. Fabry** and **A. Pérot.** (Annal. Chim. Phys. 22 pp. 564–574, April, 1901.)—The authors have for some time past been working with experimental apparatus in determining constants of length in terms of the wave lengths of various spectrum lines, and have had an instrument made embodying the improvements suggested by experience. This article contains details of the new instrument, illustrated by several engravings. C. P. B.

1893. *Simple Proof of Kirchhoff's Law of Radiation.* **E. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 3. 7. pp. 81–84, 1901.)—This proof of Kirchhoff's law was partly contained in the report which the author read before the Paris Congress [Abstract No. 1070 (1901)]. It does not assume (as Kirchhoff's proof did) that perfectly black bodies, perfect reflectors and completely diathermanous bodies are possible. J. B. H.

1894. *Reflection and Refraction of Light.* **G. Sagnac.** (Archives Néerlandaises, 5. pp. 377–394, 1900.)—The author describes his theory of the propagation of light based on the discontinuity of matter, and applies it to the reflection and refraction of light in glass. He gives a more extended account of some parts of his theory which has already been described in *Science Abstracts.* J. J. S.

1895. *Arc Spectrum of Vanadium.* **J. N. Lockyer** and **F. E. Baxandall.** (Roy. Soc., Proc. 68. pp. 189–210, May 23, 1901.)—This paper gives a list of the vanadium lines reduced from photographs of the arc spectrum of vanadic chloride and oxide obtained by C. P. Butler with a large Rowland concave grating of 21½ feet radius. A discussion is given of the relations to other lists of vanadium lines published by Rowland and Harrison, and Hasselberg. C. P. B.

1896. *Spectroscopy Applied to Biology.* **A. Hénocque.** (International Physical Congress at Paris, Report, 3. pp. 586–614, 1900.)—The author deals with the methods employed for examining blood in its normal and its pathological states, the use of the spectroscope and hematoscope in physiological and clinical researches, and the spectroscopy of animal and vegetable pigments. E. E. F.

1897. *Diffraction Image of Slit.* **C. H. Wind.** (Phys. Zeitschr. 2. pp. 265–267, Feb. 2, 1901.)—Two drawings shown have been made from short and long exposure photographs respectively of a V-shaped slit illuminated by a point source. These show up the detail of the bands in geometrical image and shadow. A fine drawing has also been made, using Cornu's spiral, giving the lines of equal intensity of illumination over image and shadow. Two errors are noted in Gilbert's tables of the values of Fresnel's sine integrals. G. E. A.

1898. *Dispersion of Jena Glasses in the Ultra-violet.* **H. Trommsdorff.** (Phys. Zeitschr. 2. pp. 576–578, June 29, 1901.)—This Abstract of the author's Inaugural Dissertation in Jena (1901), contains an account of the method of experimenting, but the experimental results are not given. J. B. H.

1899. *Radiation of a Black Body.* **W. Michelson.** (Phys. Zeitschr. 2. p. 576, June 29, 1901.)—The author here replies to a criticism of his work which Lummer made in his Report to the Paris Congress [see Abstract No. 1045 (1901)]. J. B. H.

HEAT.

1900. *Persistent Changes in Glass and Shift of the Zero-point in Thermometers.* **L. Marchis.** (Zeitschr. Phys. Chem. 37. pp. 553–604, June 28, 1901.)—This is in continuation of a former paper [see Abstract No. 1686 (1899)] and deals with the hardening and annealing of glass, which is looked upon as a substance whose changes of condition are subject to hysteresis, so that its condition at any moment requires for complete specification some other variable in addition to, say, t and v. This variable, denoted by x, is called the "hardness"; it is taken as the measure of an assumed chemical condition which is subject to change, but of which nothing is known except from the experimental confirmation of results deduced from the hypothesis of its existence. The paper is too complex to be briefly abstracted, but the investigation follows the lines sketched in the above-named Abstract. A general conclusion is that for an isolated observation of a system subject to hysteresis to be of any real value the history of the variations of this system both before and after this observation must be known. R. E. B.

1901. *Thermometry of Precision.* **L. Marchis.** (Zeitschr. Phys. Chem. 37. pp. 605–612, June 28, 1901.)—The theory developed in the preceding memoir is here applied to explain the rationality of the procedure adopted on empirical grounds by the makers of thermometers for precise work, and some further practical details are described which the author's own investigations have suggested. The necessity of heating a thermometer to 100° and quickly cooling it to 0° some fifty or sixty times in succession before marking the fixed points is insisted upon, and also of repeating this process ten or fifteen times each time a thermometer is brought into use after lying by for a time in a place of practically constant temperature; and the practice of keeping a thermometer, which is to be used for a long series of temperature-determinations within a short range, *continuously* within that range, and of testing the shift of its zero-point only by an *auxiliary* thermometer, is theoretically justified. R. E. B.

1902. *Thermometer Glass at High Temperatures.* **W. McClellan.** (Frank. Inst., Journ. 152. pp. 63–72, July, 1901.) The experiments described in this paper are on the creeping of the fixed points of mercury-in-glass thermometers with time, particularly high temperature thermometers containing nitrogen under pressure. The experiments show that the creeping is greatly facilitated by keeping the thermometer for a long time at a high temperature. The creeping is really due to an annealing of the glass, and ceases when the annealing is complete. J. B. H.

1903. *Specific Heat of Alloys.* **D. Mazzotto.** (Journ. de Physique, 10. pp. 279–281, April, 1901.)—As regards the discrepancies between the various specific heats attributed to alloys, which were pointed out by van Aubel [see Abstract No. 72 (1901)], the author shows that these discrepancies are altogether systematic. In determining by the cooling method the specific heat of Lipowitz's or other alloys, either high values may be obtained, resembling those found by Spring, or the lower values which the author considers the

true ones. The high values are obtained by subjecting the alloy to cooling after taking it beyond the fusing-point, and the low values by allowing the alloy to cool after keeping it for a considerable time at a temperature just below fusing-point. Thus for the same alloy, that of Lipowitz, the specific heat between 15° and 20° is 0·0476 by the first method and 0·0357 by the second method. The same applies to Wood's alloy. As regards those of Rose and Darcet, the heat developed by molecular change not only delays the cooling of the solidified alloy, but even heats it up. E. E. F.

1904. *Gay Lussac's Laws.* **A. Ponsot.** (Comptes Rendus, 132. pp. 1401–1404, June 10, 1901.)—These laws are only approximately adhered to, however small may be the pressure: the phenomena of dissociation show this. V being volume, m the number of molecules dissociated, T the temperature; that dV/dm is positive at constant temperature and pressure is a necessary consequence of dm/dT being positive. When the equilibrium is independent of or affected by the pressure it is independent of or affected by the temperature, and *vice versâ*. The dissociation tends to become complete when $V=\infty$, or when $T=\infty$. The volume of a component gas is always smaller than the volumes of the components into which it is broken up by dissociation. Boyle's law is also a limiting law when $V=\infty$; but Avogadro's is not. A. D.

1905. *Thermal Conductivity of the Human Skin.* **J. Lefèvre.** (Journ. de Physique, 10. pp. 380–388, June, 1901.)—The author made absolute determinations of the thermal conductivity of the living skin by measuring or calculating the coefficient of heat emission from the external surface h, the coefficient of the heat transmission through the skin k, and the coefficient of the heat restoration on the inner surface of the skin l. The subject was immersed, always to exactly the same depth, in 68 litres of water at temperatures of 5, 12, 18, 24, and 30° C.; the skin area in contact with the water was estimated with the aid of a tightly-fitting garment. The external skin temperature was measured with the help of a thermocouple, consisting of a disc of iron surrounded by a flat ring of German silver, contained in an ebonite tube; the inner temperature by inserting a thermocouple of needle shape, likewise contained in an ebonite tube, vertically through the skin to the depth of 2 mm., the skin thickness being about 1·5 or 2 mm. The coefficient k is found to be of the order of the conductivity of guttapercha, namely, 0 00083 at 30° C., and only 0·00047 at 5°. The heat emission h from the skin varied little with the temperature of the external medium. But the l was 0 00020 at 30° and increased rapidly as the temperature of the external medium was diminished to 0·00120 at 5°. H. B.

1906. *Atomic and Molecular Volumes.* **J. Traube.** (Ann. d. Physik, 5. 3. pp. 548–564, June, 1901.)—This is a discussion of the results of many calculations from data given by S. Young and others. Two of the conclusions are that for liquids, just as for gases, we must distinguish *three* volumes, viz., that of the actual material of the atoms, that made up of the sum of the atomic volumes which equals van der Waals' b, and a molecular co-volume or excess of the molecular volume over b; and that b increases in the ratio $1:\sqrt{2}$ as a liquid changes into a gas. The ratio of the volume of a substance at absolute zero to its volume at the critical point is also estimated as 1 : 3·88 on the average. R. E. B.

1907. *Heat Absorption by Carbon Dioxide.* **S. Arrhenius.** (Ann. d. Physik, 4. 4. pp. 690–705, 1901. Paper read before the Swedish Academy of Science, Jan. 9, 1901.)—The heat sources used were a Leslie's cube at 100°, and a hollow copper vessel kept at — 80° C. by a freezing mixture applied externally. The rays were passed along a thick iron tube closed by rock-salt end plates 1 cm. thick, and filled with CO_2 from a cylinder, a thermopile acting as receiver. By taking length of tube × pressure in atmospheres (l) as the equivalent length of the CO_2 column, numbers are found which agree well with Tyndall's, and which extend the observations up to an equivalent length of 355 cm. They are also in fair agreement with those calculated from the empirical formula :

$$\log a = -\mathrm{D}\left\{(1+\mathrm{B}l)^c - 1\right\}$$

where $a = 1 - \frac{\mathrm{A}}{100}$, A being the percentage absorption.

D = 0·0028 for the first source, and
0·0040 for the second.

B = 1 and $c = 0{\cdot}25$.

The above formula is applicable between $l = 10$ and $l = 350$. The problem of heat absorption by the earth's atmosphere is then speculated upon, and Ångström's treatment of it [Abstract No. 807 (1901)] criticised adversely.
G. E. A.

1908. *Ratio of Specific Heats of Gases.* **W. P. Boynton.** (Phys. Rev. 12. pp. 353–358, June, 1901.)—Van der Waals' characteristic gives for this ratio—

$$1 + (\mathrm{R}/\mathrm{C}_v)\left\{1 + 2a(v-b)/(pv^3 - av + 2ab)\right\},$$

which is represented by $1 + (\mathrm{R}/\mathrm{C}_v)(1 + 2a/pv^2)$ with sufficient approximation under ordinary circumstances. Another formula is obtained by assuming that with this characteristic the ratio is equal to V^2/pv, where V is the velocity of sound in the gas [but the percentage-error of the whole ratio on this assumption is equal to that of the correctional-term $2a/pv^2$ in the other formula]. A third formula [still less approximate] is given, and all three are compared by calculations for air, H_2 and CO_2. R. E. B.

1909. *Mechanical Interpretation of the Principles of Thermodynamics.* **A. Séligmann-Lui.** (Comptes Rendus, 133. pp. 30–33, July 1, 1901.)—For the motion of a conservative system to be stable ΣdV must always be zero, as also is ΣdU, where U and V are respectively the whole energy and the kinetic energy of the system, and Σ extends over all its parts. For no part to gain energy at the expense of another dU/dV must be the same everywhere, and it is characteristic of the temperature T, or is $f(T)$. If in a Carnot's cycle dV is the kinetic energy lost by the source at T_2, and gained by that at T_1, the whole energy lost by the former is $f(T_1)dV$ and that gained by the latter is $f(T_2)dV$, so that the efficiency is $1 - f(T_2)/f(T_1)$, and thus $dU/dV = MT$, where M is independent of the working body and of T. The kinetic energy V is then identified with the entropy $\int dU/T$: further, M must be positive. It is concluded from this that the kinetic energy of gases is a function of their volume, and that therefore the kinetic theory of gases must be entirely abandoned ; also that, if during any transformation a body has received increments ΔU and ΔV of intrinsic and kinetic energy from bodies at T, the part of ΔU made up of electrical energy cannot exceed $MT\,\Delta V - \Delta U$.
R. E. B.

1910. *The Characteristic Equation and the Theory of Cyclical Motion.* **J. D. van der Waals.** (Archives Néerlandaises, 4. 3. pp. 231–269, 1901.)—The theory of cyclical motion applied to a diatomic gas gives—

$$\{p + (\partial P_v/\partial v)_T\}(v-b) = \frac{2}{3}L_m$$

$$\{p + (\partial P_v/\partial v)_T + (\partial P_b/\partial b)_T\}(b-b_o) = 2L_a$$

for the molecular and atomic motions respectively, L_m and L_a being the corresponding kinetic energies, P_v and b being functions of v and T, P_b a function of b and T, and b_o the value of b for $T=0$, $p=\infty$. Further, since $L_m = \frac{3}{2}RT$, the entropy is given by—

$$d\eta = \frac{3}{2}R\left[d.\log\{v-b)^{\frac{2}{3}}L_m\} + (L_a/L_m)\,d.\log\{(b-b_o)^2L_a\}\right],$$

which for integration requires L_a/L_m to be constant or a function of $(b-b_o)^2L_a$: reasons are given for assuming this ratio equal to $\frac{1}{3}$, whence—

$$\eta = R\log\{(v-b)(b-b_o)T^2\},$$

from which is obtained, on not very clear grounds, for infinite dilution, $C_v = \frac{5}{2}R$, and consequently $C_p/C_v = 1{\cdot}4$. The above results follow from ordinary thermodynamics assuming that the characteristic and the intrinsic energy of a gas are respectively of the forms—

$$\{p + (\partial P_v/\partial v)_T\}(v-b) = RT$$

$$\epsilon = F(T) - T^2\partial_v(P_v/T)/\partial T - T^2\partial_b(P_b/T)/\partial T,$$

which give in general—

$$p + (\partial P_v/\partial v)_T + (\partial P_b/\partial b)_T = RTF(b-b_o).$$

For a triatomic gas the matter is more complicated, but a near approximation seems to be—

$$p + av^{-2} + \alpha(b-b_o) = fRT/(b-b_o),$$

where a, α, f are constants, and $2 > f > 1$. Complicated calculations from the data for CO_2 lead to the conclusion that b is independent of T and given by—

$$\frac{1}{2}(b-b_o)/(v-b) = 1 - \{(b-b_o)/(b_l-b_o)\}^2,$$

where b_l is the value of b for $v=\infty$; and for this gas $f \doteq 2$, $a = 0{\cdot}00874$, $\alpha = 0{\cdot}138$, $b_o \doteq 0{\cdot}0007$, $b_l \doteq 0{\cdot}0026$.

A general conclusion from the theory is that as matter becomes more and more condensed, its state approximates to that in which all the molecules are resolved into atoms. R. E. B.

SOUND.

1911. *Monaural Localisation of Sound.* **J. R. Angell.** (Science, 13. pp. 775–777, May 17, 1901; also Psychological Review, May, 1901.)—The subject of the experiments was a man totally deaf in one ear, total nerve deafness indicating disease of the labyrinth of that side. The uninjured ear was decidedly more acute than the average.

Imagine the man seated in the centre of a large clock-face, the XII being in front of him, the VI behind, the III and IX being to his right and left respectively, and the left ear being the deaf one.

Pure tones, such as the sounds of tuning-forks, cannot be localised at all. Complex sounds can be localised with an ease which increases with the number and audible nature of the partial tones, except in the region from VIII to X, *i.e.*, directly opposite the deaf ear. In monaural hearing intensity of the sound can only afford very ambiguous information, as an alteration may be due to change of distance, change of intensity in the note itself, or change in direction. The subject cannot localise simple sounds, for they are capable of variation only as regards intensity. Complex sounds he can localise, no matter how the distance or intensity varies. Localisation seems, therefore, to be due to the modifying of the partial tones, to which the meatus pinna and the bones of the head all contribute. W. C. O.

1912. *Sounding Flames and Flame Telephony.* **H. T. Simon.** (Elektrotechn. Zeitschr. 22. pp. 510–514, June 20, 1901. Paper read before the Elektrotechn. Verein, April 23, 1901.)—The author observed in 1898 that an arc-lamp reproduced the chatter of an induction coil worked in the next room: it was found that the two circuits were parallel to one another for a very short distance, and the steady current in the lamp circuit had interrupted induced currents superimposed upon it: but these could only be very small; so microphone currents were tried, passed through one coil of a transformer while the lamp current was passed through the other; and the experiment succeeded, the arc-lamp giving out the sound without change of timbre, like an ideal loud-speaking telephone. Microphones for currents up to $\frac{1}{2}$ ampere gave the best results. The next improvement (E. Ruhmer) was to put the microphone with a resistance in parallel with the lamp: this got rid of the transformer and of the microphone battery. Then came Duddell's remarkable work (The Electrician, Dec., 1900), in which capacity and self-induction are taken account of in such a way as to confine the microphone currents to the flame and to exclude them from the general system. He put a capacity and a transformer in parallel with the lamp, and passed the microphone current through one coil of the transformer. This was an improvement, but the author and Reich have found that, when the lamp is fed by an accumulator battery, Duddell's arrangement may even be harmful, but that it must be used when the lamp circuit has much self-induction and particularly when a dynamo is used. But it may be pointed out that in Duddell's system resonance, which can only reinforce one component, must be avoided; and the self-induction and capacity must be so chosen that for the deepest note to be reproduced (say $n = 300$ per second), $2\pi n$ shall not be equal to but shall always be greater than $1/\sqrt{LC}$: say L is that of a thick-wired 300-turn coil and C is

5 microfarads. If C be too great, the condenser does not come up to full charges at each oscillation, and the effect is deteriorated. Other combinations may be used; and one devised both by the author and Reich and also by Ruhmer, is to put a capacity across the lamp circuit and between this and the lamp to branch a microphone circuit on the lamp circuit with both a self-induction and a resistance on the main circuit between the ends of the microphone branch, the resistance being such that the voltage on the microphone is about 4 volts. The loudness increases with the strength of the lamp-current and with the length of the arc. Duddell first had the boldness to use arcs of 10 cm., such as are now used; either impregnating his carbons with salts or using sufficient voltages (110 to 200 volts). The volume of the arc seems to undergo periodical variations in consequence of the varying heating; the consequence of this is the production of air-waves. The variations of temperature would be about 0·3° C., which is sufficient. Explanations have been put forward according to which the vibration is due to a varying current in the terrestrial magnetic field: but the sound is not made louder through putting the arc in a strong magnetic field. The author is still experimenting as to the cause of the phenomenon, in the light of the more recent knowledge as to the conduction of electricity in gases. Braun has pointed out that the increment in the Joule effect is proportional to $i \cdot \delta i \cdot r$, and should therefore be greater the stronger the lamp-current: but we cannot treat the lamp as a simple metallic conductor, though there does seem to be a true Ohm effect. Experiment is going on as to this; but in the meantime it would seem that Braun is right. The converse phenomenon would be the impact of sound waves effecting an alteration in the volume of the arc gases, and this producing variations in the current in the lamp-circuit, which might be reproduced as sound in a telephone: so that an arc-lamp might be used as a microphone. This can be done if the sound waves be concentrated upon an arc confined in a lime block. More faintly, an arc lamp may repeat what has been said near another arc-lamp in the same circuit with it (J. H. West). By taking the current of the field magnets of a (shunt) dynamo through one coil of a transformer, and through the other coil a microphone current; and by putting a capacity across the field magnet shunt and a choking coil in the shunt, we can make all the lamps on the circuit speak simultaneously. Some recent tests in Frankfurt have been conspicuously successful in this; but with ordinary lamps a suitable capacity must be arranged in parallel with the main-current coil of the regulator. With alternating currents there is both the transmitted sound and the tone belonging to the alternations. With three-phase currents, if we take the light of three wires and three carbons at 120° on to one carbon, and pass the microphone currents over the field magnets, we can produce the same effect as with a direct current; apart always from the imperfection introduced by departures from the sinusoidal curve. For telephony without wires, we might use selenium cells, which have recently been greatly improved (Clausen and v. Bronk, Berlin), having now a resistance of 18,000 ohms in the dark and 9,000 ohms in diffused daylight, and being now prompt in response. As the temperature of the arc varies the radiations vary: and this is sufficient to work a telephone. Graham Bell's photophone of 1880—a vibrating membrane, silvered, reflecting light on to a selenium cell—could not work beyond 250 metres: the present plan disposes of far more powerful beams, which may be concentrated as we wish. The selenium cell is so sensitive that if a Siemens and Halske polarised relay be arranged in its circuit so as to operate the circuit of an incandescent lamp, it is sufficient to light a match at some distance from the selenium cell to make

the incandescent lamp light up. The Arons lamp works well for this kind of photophonic transmission : an arc between mercury electrodes in a vacuum : the arc itself is silent and the only variations are in its intensity. The constant current of the selenium cell is kept from the telephone by connecting one terminal of the telephone with a condenser arranged parallel to the selenium cell. Ruhmer has photographed the variations of radiation upon a moving film : and on again passing this film between a light and a selenium cell, with telephone, he has obtained a reproduction of the original speech. Duddell has obtained a sinusoidal current from a direct by putting a low-resistance self-induction and a capacity in parallel with a lamp ; the lamp spontaneously gives a sound corresponding to the value of n : a result which is of extreme importance from the technical point of view, since L and C may be adjusted so as to give n any required value, and the pure sinusoidal form is of great consequence in wireless telegraphy. Much remains to be done in the study of selenium cells. [See also Abstracts Nos. 846, 850, 1090, and 1234 (1901).]

A. D.

1913. *Velocity of Sound in Hot Air.* **E. H. Stevens.** (Deutsch. Phys. Gesell., Verh. 3. 5. pp. 54–56, 1901.)—The velocity of sound in hot air was found by means of a resonance tube of porcelain closed at one end, which was heated in a coal stove. The first mode was determined by displacing a narrow hearing tube in the resonance tube until the note vanished. The velocity at 950° was found to be 686 m. per sec., instead of the theoretical value 701·8. This gives 1·34 for the ratio k of the two specific heats. Further experiments were made with an electrically heated tube. It was found that the divergence between theoretical and actual values increases with the temperature. At 1,000° the actual velocity is 700·3 m. per second instead of 716, and k is 1·340.

E. E. F

ELECTRICITY AND MAGNETISM

THEORY AND ELECTROSTATICS.

1914. *On the Maximum Value and Physical Significance of Maxwell's Function T_{me}.* **A. Garbasso.** (N. Cimento, 1. pp. 401–444, June, 1901.)—This treatise refers to Maxwell's division of the kinetic energy of a system of electric currents in material bodies into three parts, T_m, T_e, and T_{me}, in which T_m is the kinetic energy of moving masses assuming no currents to exist, T_e the kinetic energy of the currents, the masses being at rest, and T_{me} that part if any of the kinetic energy which is due to the simultaneous existence of electric currents and moving masses. The Lagrangian force component is similarly divided into X_m, X_e, and X_{me}. It may be put also into the form $K\dot{x}\dot{y}$, if x be the angle turned through by a circuit revolving about an axis, y the quantity of electricity which has passed through a section of current since a given epoch. Any such term depends for its existence on a connecting link between matter and electricity.

Maxwell concludes that no such term, and therefore no such connection, exists. The experiment which led him to this conclusion is described in Electricity and Magnetism, vol. ii. p. 201. The writer considers Maxwell's experiment inconclusive, on the ground mainly that the mercury into which the end of the wire is dipped tends to extinguish the force X_{me}, if it exists.

The writer proposes to introduce an electromotive force reducing to zero a magnetic field, thereby avoiding the damping or extinguishing of the motion which would follow from Foucault's currents. Such an e.m.f. may, for instance, be formed by exciting an electric current in a metallic ring; and he discusses what is the best metal for the ring, having regard to density and specific resistance, and what is its best form. The apparatus employed by the writer is described, and its principal constants calculated by the aid of the theoretical formulæ. The results obtained are: (1) To a first approximation everything goes on as if no connection existed between the motion of electricity and that of matter; (2) but taking into account higher terms of a series there is room for the hypothesis that such connection exists, and that it has special properties; (3) if in certain cases a term $K\dot{x}\dot{y}$ is found to exist, then the connection above must exist. It does not, however, follow that we can in any given case determine with certainty the direction of the current in the conductors. S. H. B

1915. *On the Internal Tensions of a Fluid Magnetically or Dielectrically Polarised.* **L. Giuganino.** (N. Cimento, 2. pp. 20–41, July, 1901.)—The writer examines certain developments by Duhem and Helmholtz of Maxwell's theory, which represents magnetic and electrical phenomena by a system of elastic pressures and tensions in a fluid surrounding the magnetised or electrified bodies.

He assumes a perfect fluid capable of magnetic polarisation, whose specific volume at x, y, z is denoted by σ, and its thermodynamic potential at constant volume is—

$$\int \phi(\sigma) d\omega,$$

the integral being throughout space. A magnetic field having potential V i

reated. This polarises the fluid, and the potential of the polarised mass is U. A, B, C are components of the induced magnetisation, and $A = M \cos(Mx)$, &c. The thermodynamic potential can be put in the form—

$$\Omega = \int \phi(\sigma) d\omega + \int A \frac{dV}{dx} d\omega + \&c.$$
$$+ \frac{1}{2} \int A \frac{dU}{dx} d\omega + \&c.$$
$$+ \int F(M\sigma) d\omega,$$

where F denotes a certain function. He finds that if σ varies and $\partial\sigma$ denotes the consequent variation, and u, v, w the displacements of x, y, z, then—

$$\partial_\sigma \Omega = \int \left\{ \frac{\partial}{\partial \sigma} [\sigma F(M\sigma)] + \frac{1}{2} \frac{\partial (U + 2V)}{\partial x} A + \&c. \right\} \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} \right) d\omega,$$

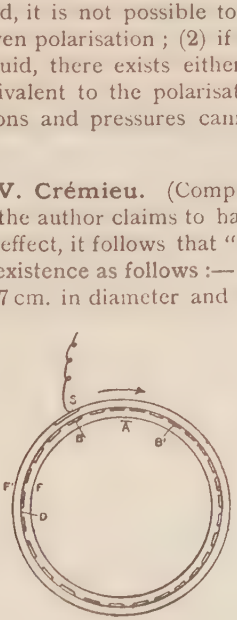
which differs from Duhem's theory by the integral—

$$\int \left(\frac{1}{2} \frac{\partial (U + 2V)}{\partial x} A + \&c. \right) \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} \right) d\omega$$

In like manner, considering Helmholtz's theory, he finds that certain terms are not correctly given. His conclusions are: (1) If a polarised body which is compressible has only induced electric or magnetic charges, and can be considered as a perfect fluid, it is not possible to find any system of elastic forces equivalent to the given polarisation; (2) if the polarised body be considered as an imperfect fluid, there exists either an infinity of systems of tensions and pressures equivalent to the polarisation or none at all; (3) the expression for these tensions and pressures cannot be reduced to that of Maxwell and Helmholtz. S. H. B.

1916. *Open Currents.* **V. Crémieu.** (Comptes Rendus, 132. pp. 1108–1110, May 6, 1901.)—If, as the author claims to have proved, electric convection produces no magnetic effect, it follows that "open currents" must exist, and he demonstrates their existence as follows:—

On an ebonite disc D, 37 cm. in diameter and 2·5 mm. thick, 25 segments



are gilt. The disc turns about a central axis between two fixed ebonite discs F and F'. The disc F' bears a tin-foil armature S twice as broad as the moving armatures. Two brushes, B, B', 60 degrees apart, are in contact with the moving armatures. When S is charged, the armature in contact with B acquires an induced charge, which passes on to B', where it is discharged. If B and B' are connected there will be electric convection between them on

the one hand and electric conduction on the other. At A is placed one needle of an astatic system. If B and B′ are joined through a galvanometer the latter shows a deflection while A does not. If B and B′ are joined through a coil placed near the lower needle of the astatic pair, a deflection of A is observed as soon as S is charged, and varying in direction with the sign of the charge. The current circulating in BB′B is therefore an open current. [See also Abstracts Nos. 1666 (1900), 144 and 1100 (1901)]. E. E. F

DISCHARGE AND OSCILLATIONS.

1917. *Electricity Dispersion in Higher Atmospheric Strata.* **H. Ebert** (Ann. d. Physik, 5. 3. pp. 718–724, June, 1901.)—Abstract from Bayer. Akad Wiss. Sitz. Ber. Math.-Phys. Klasse, 30. p. 511, 1900 ; 31, p. 35, 1901.)—Together with R. Emden, the author made three balloon ascents on June 30 and Nov. 19 (mist below), 1900, and Jan. 17, 1901 (clear day, country covered with snow). Determinations of dispersion were made by Elster and Geitel's method. Near the surface, the dispersion of negative charges is much more rapid than that of positive charges, so that a kind of unipolar conduction results. In higher strata both discharges become much more rapid, and the difference between the positive and negative discharges tends to disappear. In the serene atmosphere above 3,000 m. the two dispersions were practically equal. Much depends, however, on the atmospheric conditions, and the unipolarity may extend into the higher strata. Water condensation impedes the mobility of the ions. H. E

1918. *Electric Leakage in Enclosed Volumes of Air.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 2. pp. 560–563, June 22, 1901.)—Following on Geitel's earlier experiments [see Abstract No. 635 (1901)] the authors seek to determine the cause of the electrical conductivity which is observed in air even in the absence of all influences known to produce such conductivity. They find that the gradual increase of conductivity up to a certain limiting value cannot be due, except to an insignificant extent, to the settling of dust originally present in suspension, nor yet to variations of humidity of the air. In caves and in cellars of houses, where the air is almost stagnant, an abnormally high conductivity was found. Since the enclosed air behaves as if there were present in itself or in the enclosing walls small traces of radio-active substances, it appears possible that either the radio-active substances at present known are scattered everywhere, or that radio-activity is itself a property belonging to a small extent to other bodies also. W. C. R

1919. *Influence of Temperature upon Photo-electric Effect.* **J. Zeleny** (Phys. Rev. 12. pp. 321–339, June, 1901.)—The author describes, and gives the results of, experiments on the influence of the temperature of a body upon the rate at which electricity is discharged from its surface by ultra-violet light. From a platinum wire the negative electricity is at first discharged more slowly as the temperature is increased ; but the rate of discharge reaches a minimum and then increases as far as the highest temperature used (about 700° C.). The rate of discharge produced by the light also depends upon the previous history of the wire. When the wire comes to a certain temperature from a higher one, the rate of discharge is much greater than if a lower temperature had been used just before. After the reduction of temperature the rate of discharge gradually becomes smaller with time, showing that the lar

onductivity at first is due, partly at least, to the fact that the wire reaches its teady state but slowly. With an iron wire we also find a descent at first to a inimum rate of discharge, but the final value is many times that for ordinary oom temperature.

Heating the wire does not change the inability of ultra-violet light to ischarge positive electricity, even though the wire is raised to a temperature here, on account of the heat alone, the positive electricity is being dis-harged. From the nature of the results of the above experiments the author oncludes that the variations observed are mostly due to changes taking place t the metal surface, and not in the gas between the electrodes. The experi-ments are to be continued. W. C. H.

1920. *Spark Discharge accompanying High-frequency Oscillations.* **K. E. Guthe.** (Ann. d. Physik, 5. 4. pp. 818–828, July, 1901.)—A small jar is pro-vided with a spark-gap upon which ultra-violet rays are incident, and its spark potential is known. This jar is then charged in an oscillatory manner from a larger jar through a connection having appreciable inductance and resistance. It, at first, appeared as though the spark potential of the smaller jar was not now the same as under statical conditions. Careful experiments and calculations, however, establish that the jar sparks, during the surgings, immediately the "static" value of potential is reached. E. H. B.

1921. *Electric Discharge in Helium.* **W. Heuse.** (Ann. d. Physik, 5. 3. pp. 678–684, June, 1901.)—Collie and Ramsay have stated that a tube containing helium shows, at atmospheric pressure, the appearances usually looked for in other gases at greatly reduced pressures when an electric discharge is passed. The author here shows that a helium tube gives the same form of discharge at a pressure of 28 mm. as does a hydrogen tube at 4 mm., and that the stratified discharge can be produced in helium at 5 mm., while in nitrogen, in the same tube, 1 mm. is the highest pressure at which stratifications appear. The potential gradient in helium is very small as compared with other gases under similar conditions. The kathode fall of potential in the same gas is given as 253 volts. The potential gradient along the whole length of a tube containing helium was measured and was found to give results similar to those obtained by Graham for nitrogen. R. S. W.

1922. *Anode Rays.* **W. Hibbert.** (Elect. Rev. 48. pp. 962–963, June 7, 1901.)—During exhaustion of a tube there are both anode and kathode rays. The line of discharge and concentration for each varies according to the pressure. At particular, though differing, pressures it is possible to get conver-gence of either. A. D.

1923. *Potential Distribution near the Kathode.* **A. Wehnelt.** (Phys. Zeitschr. 2. pp. 518–527, June 1, 1901.)—By means of a special tube the author is able to measure the potential at points in the discharge not only along the axis but along the diameter of the cross section of the tube. From numerous measurements equipotential surfaces near the kathode can be drawn. In a tube in which the disc electrode is far removed from the walls, these are smooth surfaces concave to the kathode. If the walls of the tube are near, the surface is rather more complicated. Comparatively great potential gradients are found across the section of the tube in the kathode dark space. The potential is found to rise in a continuous manner along the axis of the tube as the kathode recedes, thus disagreeing with Graham's results, the latter

finding maxima and minima. Testing the matter more under Graham's conditions, his results are shown to be due to a defect in the apparatus. At high pressures the equipotential surfaces are parallel to the kathode. The distortion of these by a magnet is investigated experimentally. The temperature of the gas carrying the discharge increases in a continuous manner as the boundary line between the dark space and negative glow is crossed. R. S. W.

1924. *Electric Resonance in Rarefied Air.* **A. Turpain.** (Comptes Rendus, 132. pp. 1315–1317, June 3, 1901.)—The methods of previous papers [Abstracts Nos. 1846 and 2246 (1900)] are extended to the wires concentrating the Hertzian field and the region surrounding these wires and the resonator. The oscillations which excite a resonator have a wave-length twice the length of the resonator. A. D.

1925. *Passage of Electric Waves through Systems of Resonators.* **E. Aschkinass** and **C. Schaefer.** (Ann. d. Physik, 5. 3. pp. 489–500, June, 1901.)—In the endeavour to clear up certain problems as to the mechanism of optical absorption and dispersion the following experiments with electric waves were conducted. A parallel beam of electric waves of length 9 cm. in air was generated and allowed to fall upon a set of small resonators equally spaced throughout a wooden frame a foot square. Ten such sets of resonators of various sizes were made and used in succession in air and immersed in various liquids to find in each case which set gave the maximum absorption of the waves. The lengths of the waves in the various liquids were thus determined. The ratio of wave-lengths in air and in a liquid, compared with the square root of its dielectric constant, gave a good agreement for the liquids tested, as follows :—

Liquid.	Ratio of Wave-lengths.	$\sqrt{K}$
Benzol	1·52	1·52
Ether	2·04	2·07
Acetone	4·7	4·6

E. H. B.

1926. *Application of the Calorimeter to Measurement of Electric Waves.* **F. Harms.** (Ann. d. Physik, 5. 3. pp. 565–596, June, 1901.)—By adoption of a convenient calorimetric method for the detection of electric waves the following results were obtained :—

(1) A series of substances were proved to exhibit anomalous electric absorption.

(2) This anomalous electric absorption is connected with an increased conductivity.

(3) The theoretically derived law, as to the variation of conductivity with frequency of vibration, is approximately confirmed by the experiments.

(4) The decrease of resistance of alloys to high-frequency vibrations, to be expected on Liebenow's theory, was not with certainty detected with wave lengths from 14 to 5 metres. E. H. B.

1927. *Theory of Hertzian Oscillations.* **K. R. Johnson.** (Journ. de Physique, 10. pp. 365–374, June, 1901.)—The period of oscillation of Hertz waves depends on the dimensions of the exciter, and the recognised complete theory considers that for a certain spark-gap there is a certain conductibility of the same order as that of the conductor. Cornu, Hagenbach, and Zehnder and Baille have all pointed out difficulties as regards the theory of the spark-gap. Moll has shown long ago that card is pierced only from one side in a spark-gap, and it was only by change in the current of the inductor that the punctures were reversed, and then they were always in one direction. According to Poincaré, photographs indicate that the first spark is the only one, and that this gives the propulsion to the oscillations which follow. In short, all direct experiment is opposed to the view that the gap resistance suddenly falls from, say, 1,000 megohms to 10 ohms, and persists at the low resistance for an appreciable time. The author proceeds to examine the simple electrodynamic theory of the circuits, taking cases when capacity is very great or nil or infinity. He concludes that it is not necessary to have two theories of action (1) for the exciter and (2) for the resonator, and that all theories by which new properties are attributed to the explosive distance are useless. P. E. S.

1928. *Singing Arc-Lamps.* **W. Peukert.** (Elektrotechn. Zeitschr. 22. pp. 467–468, June 6, 1901.)—The author arranged a direct-current arc-lamp with a choking coil, and between the arc and the choking coil he took off a branch in parallel, from carbon to carbon, this branch carrying a condenser and a key. On depressing the key it was found that for a particular length of arc (with a small range of variation), say $\frac{3}{4}$ mm., the arc sings out a high-pitched note (varying according to the length of the arc). The current in the condenser branch undergoes oscillations whose period is $T = 2\pi\sqrt{CL}$, say 9,000 per second; and the voltage at the condenser is, say, 40 volts. This enables low-pressure alternating currents of extremely high frequency to be obtained. With such currents it is easy to obtain all the results characteristic of high-frequency currents. [*Cf.* Abstracts Nos. 846, 850, and 1234 (1901).] A. D.

1929. *Electric Oscillations in Metal Rods.* **F. Kiebitz.** (Ann. d. Physik, 5. 4. pp. 872–904, July, 1901.)—The experimental method adopted is like that used by v. Bjerknes, but the author in most of his experiments on intensity of resonance uses a small electrometer with a single moving vane mounted on a quartz fibre.

The conclusions arrived at are :—

1. A rod-oscillator radiates harmonics as well as the fundamental radiations; the frequencies of the harmonics are odd multiples of the fundamental frequency. The existence of eight such harmonics was verified. Their intensities are very small compared with that of the fundamental.

2. Oscillators of other than rod-forms also radiate *overtones*, but these are not harmonics of the fundamental.

3. The node- and antinode-surfaces of the magnetic force in the neighbourhood of rod-oscillators agree approximately with the theoretical surfaces calculated by Abraham, *i.e.*, they are approximately hyperboloids of revolution having their foci at the outer ends of the rods and centre at the centre of the oscillator.

4. The damping of the oscillations is greater the smaller the distance between transmitting and receiving resonators.

5. In the case of the fundamental vibrations the logarithmic decrement in the receiver was 0·154 at 2 m. distance and for the first harmonic 0·182 at 30 cm. distance from the transmitter. These decrements are correct to 10 or 15 per cent.

6. The cause of the damping arises more from the radiation of energy than from heat lost at the spark in the transmitter.

7. A straight receiver does not give as good a resonance as one of circular form.

8. A coherer may be used to verify resonance, but not with a circular receiver; the straight line receiving resonator must be the same length as the transmitting resonator in this case. The coherer acts either as a conductor or as an insulator of very great capacity. J. B. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1930. *Resistance of Nickel.* **A. Campbell.** (Elect. Rev. 48. pp. 1014–1015, June 14, 1901.)—The author gives curves showing the resistance of two specimens of nickel at different temperatures up to 700° C. Both specimens were commercial, one being bought recently, the other six years ago; their resistivities are respectively 8 and 12 microhm-cms., the former value being near Fleming's figure of 6·9 for pure nickel; the older specimen has a lower temperature coefficient. The two curves show a bend at 300° C. G. H. B.

1931. *Graphic Method for Calculating the Distance of a Break in a Submarine Cable.* **E. Jona.** (Electrician, 47. pp. 333–334, June 21, 1901.)—Calculating by Kennelly's and Schaefer's methods is laborious. The author measures the currents with a Weston galvanometer of 150 ohms resistance with suitable shunts. By altering the resistances inserted in the battery circuit, he finds the currents best adapted to his calculations; further to save time he tests with a series of different currents, plotting the results in a curve in which the abscissæ are resistances, R, and ordinates are values of current, i, through the break. He uses an observation of Kennelly, that the resistance of a break varies inversely as the square root of the current if the latter is under 25 milliamperes. Then $R = x + \frac{Z}{\sqrt{i}}$, where Z is the resistance of the break, according to the false zero method. This equation represents a curve of the third order in R and i. Transforming this curve and bringing the value $1/\sqrt{i} = z$ as ordinate instead of the values of i, the author obtains a straight line, cutting the axis R at a point which indicates the distance of the break. A similar process with the true zero gives a similar result. E. O. W.

1932. *On the Behaviour of Liquids in Capillary Tubes under the Influence of an Electric Current passed through Air.* **S. Lemström.** (Ann. d. Physik, 5. 4. pp. 729–756, July, 1901.)—This paper describes a continuation of certain experiments made by the writer in 1898. In these experiments an influence machine was employed of which one pole was earthed and the other connected with a metallic point above a vertical capillary tube, the lower end of the tube being in a vessel of water, and the water connected electrically to earth. By an electric current passed through air is understood one which passes through a stratum of air of greater or less width. It was found in these experiments that under the influence of this air electric current, water rose along the sides of the tube, and formed drops in the upper end.

In the series of experiments described in this paper a Leyden jar is introduced with its inner coating connected with a zinc plate on which the water-containing glass vessel is placed. The jar is connected with a spark micrometer. Were the tube removed and the machine in action, the jar would be successively charged and discharged. On introducing the tube in the manner described, the sparking is found to increase, which proves that the conductivity of the stratum of air between the metal point and the tube has increased. The phenomenon of the rise of water along the surface of the tube and the formation of drops is observed now to take place, but only when the metal point is connected with the negative pole of the machine.

The writer discusses the different results according to different arrangements of the apparatus. In conclusion, the relation of the phenomena here described to the influence of electricity on plants is discussed with reference to former papers by the author. S. H. B.

1933. *Capacities of Polyphase Cables.* **A. Russell.** (Inst. Elect. Engin., Journ. 30. pp. 1022–1037, June, 1901.)—The author calculates that the capacity of a single-phase cable consisting of two conductors embedded in insulating material is given by—

$$K = \tfrac{1}{2}(k_{11} - k_{12}),$$

where k_{11} is the capacity of one conductor when the other is earthed, and k_{12} is the charge on the same conductor due to unit potential of the other conductor.

For a three-phase cable the author obtains the following result :—

The capacity between 1 and 2, 3, $S = k_{11}$,
„ „ 1, 2 and 3, $S = 2(k_{11} + k_{12})$,
„ „ 1, 2, 3 and $S = 3(k_{11} + 2k_{12})$,
„ „ 1 and $2 = \tfrac{1}{2}(k_{11} - k_{12})$,
„ „ 1 and 2, $3 = \tfrac{3}{2}(k_{11} - k_{12})$,

where S represents the sheath.

These formulæ are verified by experiment. W. G. R.

1934. *Alternate-current Wattmeter.* **C. V. Drysdale.** (Electrician, 46. pp. 774–778, March 15, 1901 ; also Électricien, May 4 and 11, 1901.)—The author works out formulæ for correcting wattmeter indications for self-induction and for capacity in the shunt circuit, on the assumption of a sine-wave current ; he also discusses the influence of wave-form on wattmeter indications, and how far the corrections calculated for sine-waves are applicable to other wave-forms. The errors due to eddy-currents in metal fittings on the instrument depend on the power-factor of the circuit measured, and on the specific resistance of the metal. With brass fittings the eddy-currents will not lag much more than 90° behind the main current, and will introduce errors in measuring on very inductive circuits ; with copper fittings, on the other hand, the lag will be more nearly 180°, and the errors introduced will have most effect at high power-factors. The author deprecates the use of transformers in the shunt circuit of wattmeters, except for measurement on circuits of high power-factor. A wattmeter capable of measuring a power-factor to an accuracy of 0·001 on a 100-volt circuit must have the resistance of its shunt coil at least 628,000 times its self-induction in henrys ; pivoted wattmeters cannot fulfil this condition, as they require too large a control.

Kelvin watt-balances and direct-reading wattmeters are subject to errors from the mutual induction between the series and shunt coils.

The author then describes fully with illustrations a wattmeter designed by himself; it is given a very large range by the device of winding the two series coils with eight-strand wire, each strand being insulated and connected to mercury cups, so that the 16 circuits can be connected all in parallel or in series or in any combination of the two. G. H. B.

1935. *Alternate-current Wattmeter.* **W. M. Mordey.** (Inst. Elect. Engin., Journ. 30. pp. 387–391, April, 1901.)—The instrument is constructed on the lines of a Siemens' dynamometer, in which the moving coil is replaced by a single turn of wire closed on itself; this forms the secondary of a small transformer, placed below the fixed coil, and swings in the space usually occupied by the secondary winding. The current in this moving coil is induced by the primary winding of the transformer, instead of being led in through mercury cups. If the induction in the transformer wire be sufficiently low, the current in the moving coil is proportional to the e.m.f. on the primary winding. By making the moving coil of manganin or platinoid, variation of the constant due to temperature changes are avoided. Tests at the Board of Trade laboratory show that the scale is proportional throughout; the constant, however, depends on the frequency, varying about 10 per cent. between 30 and 90 $\sim$. An important advantage is that the primary of the transformer, as well as the fixed current coils, may be variously wound and connected, so that the wattmeter can be made for a large range both of e.m.f. and current.

Discussion.—**J. A. Fleming** considered that the wattmeter had the disadvantage, in comparison with the ordinary wattmeter and separate transformer, that no experiments could be made to ascertain exactly the phase-difference between primary e.m.f. and induced current. **G. L. Addenbrooke** thought the wattmeter adapted only to circuits of high power-factor, otherwise magnetic leakage in the transformer would entirely vitiate the readings. G. H. B.

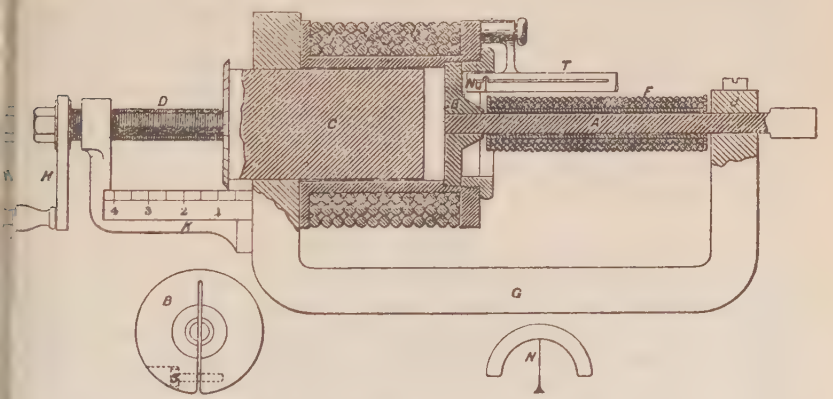
1936. *Alternate-current Wattmeters.* **C. V. Drysdale.** (Electrician, 47. p. 61, May 3, 1901.)—The writer compares the electro-dynamometer wattmeter with Addenbrooke's electrostatic wattmeter [see Abstract No. 1124 (1901)]. The latter has the advantage of being deflectional, and of having quadrants easily adjustable to make it direct reading. The dynamometer, however, requires no projection arrangement, is less delicate and much cheaper. G. H. B.

1937. *Recording Electric Instruments.* **P. Perrin.** (Soc. Int. Élect., Bull. 1. pp. 155–180; Discussion, pp. 180–184 April, 1901.)—This paper is a description of the different recording instruments shown at the Paris Exhibition of 1900. They consist for the most part of ammeters, voltmeters, and wattmeters of ordinary types with recording attachment, and call for no special mention. The clockwork is generally contained in the drum, in some cases revolving with it and in others being fixed. In certain cases provision is made for altering the rate of revolution by interchange of gear-wheels. The record is either a continuous line traced by an ink pen, or, in an instrument by Janet, by a metallic point on an impregnated paper, a current passing through the paper from the point to the drum; or the record is a dotted line produced by periodical contacts between pen and paper. An instrument of a novel type

a recorder devised by Lartigue for the insulation resistance of a network. It consists of a recording voltmeter, with a mercury switch operated periodically by the clockwork, and introducing between the main and earth a resistance of incandescent lamps. The voltmeter has two scales, one reading volts, and the other the current through the resistance; the quotient of the former by the latter gives the insulation resistance of the main including the leak caused by the voltmeter.

Discussion.—**C. Jacquin** described his experiences with recording instruments on tramways and railways. He obtained good results with glycerine dash-pots, as employed in the Richard recorders, and also with the magnetic damping used in the Meylan instruments; the damping in Arnoux and Chauvin's instruments was not sufficiently strong. G. H. B.

1938. *Permeameter.* **C. G. Lamb** and **M. Walker.** (Inst. Elect. Engin., Journ. 30. pp. 930–941; Discussion, pp. 941–944, June, 1901.)—Referring to the figure, the instrument consist of an iron yoke G, whose magnetic circuit is completed by the test-rod A, and an air-gap between the iron disc B and the iron cylinder C. The disc B has a hole to take the test-rod or server as pole-piece; the cylinder C can be moved so as to adjust the length of the air-gap, by a micrometer screw and scale. The test-rod is



7" inches long and $\frac{3}{8}$ inch in diameter. The magnetising coils E and F are wound with the same number of turns and connected in series; they act in the same direction, and consequently, if the reluctance of the test-rod and air-gap be equal, the magnetic flux will be uniform. If the reluctances be unequal there will be magnetic leakage at the pole-piece B. The presence of any leakage is shown by a small pivoted needle N, protected from air currents by a tube T with mica windows. The needle is magnetised, and is controlled by a permanent magnet so as to take up a central position when the yoke is demagnetised. To take a reading for any particular magnetising current, the air-gap is adjusted until the needle returns to its central position; the length of air-gap required to give balance can be thus determined to one-thousandth of an inch, and the value of the permeability can be found from the reading of the micrometer screw by means of a calibration curve.

The authors give details of experiments made to determine whether the calibration curve is the same for specimens differing widely in permeability; except for very low inductions, the readings of the instrument were found correct to within 1 per cent. for soft iron and for hard steel.

Discussion.—**Drysdale** suggested that if the yoke were made heavier, and the contacts better, the reluctance might be made negligible, and the instrument rendered independent of calibration. He pointed out that at high permeabilities the air-gap is very small, and therefore that the readings are subject to the greatest error under conditions when generally a high accuracy is required. G. H. B.

1939. *Differential Galvanometer.* **C. W. S. Crawley.** (Inst. Elect. Engin., Journ. 30. pp. 908–913; Discussion, pp. 913–926, June, and 1128–1129, Aug., 1901.)—The author winds a differential galvanometer double, without adjusting; in one circuit is inserted resistance to about balance when the two circuits are joined in parallel on a battery; in the other circuit is a slide-wire resistance for exact adjustment and a resistance of about $\frac{1}{1000}$ of the coil resistance, which can be cut out by a key. To compare two coils, they are joined in series with a battery, and their terminals joined to the two galvanometer circuits. If not quite equal a deflection is produced, the value of which can be found by pressing the key, which gives the value for 0·1 per cent. difference. Coils of different values can be compared by adding resistance to balance to one galvanometer circuit. The author then deals with the errors to which the method is subject, and describes a workshop method of measuring low resistances.

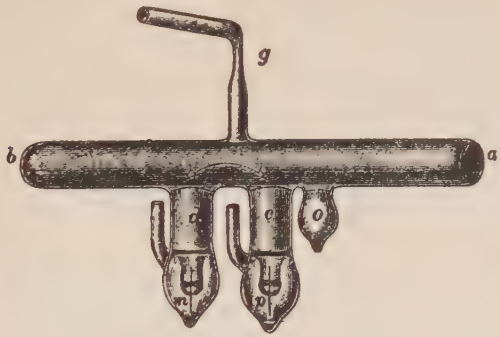
Discussion.—**A. P. Trotter** described some measurements of low resistances made at the Board of Trade Laboratory, and said he had used Crawley's method with success. **A. Russell** described the use of a differential galvanometer for measuring inductances, and as a standard of capacity; an e.m.f. is applied to the two outside terminals, when the two inner are disconnected; the capacity of the coils causes a throw of the galvanometer. **W. C. Fisher** compared the differential galvanometer method with the potentiometer, and describes some measurements made with the latter. G. H. B.

1940. *Wehnelt Interrupter.* **D. A. Goldhammer, J. J. Ariston,** and **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 557–559, June 22, and 614–615, July 20, 1901.)—In these papers the authors discuss the relative merits of certain small modifications of the Wehnelt interrupter. The addition of glycerine to the electrolyte is said to lessen the noise. Incidental reference is made to Swinton's interrupter, Electrician, 43. pp. 332–333, 1899, and to a paper on the subject by A. G. Rossi, Atti R. Acc. delle Scienze Torino, 34, 1899. R. A.

1941. *Induction Coils.* **F. Klingelfuss.** (Ann. d. Physik, 5. 4. pp. 837–871, July, 1901. From the Verh. d. naturf. Gesell. in Basel, vol. xiii.)—An attempt is here made to investigate the working of an induction coil and to find some data which would be useful in designing a coil to fulfil given conditions. Two different kinds of coil are experimented with, one having the ordinary straight core and the other having its magnetic circuit closed except for an air-gap of about 1 cm. The secondary windings are in sections so that the influence of the number of turns in the secondary on the working of the coil can be determined. The inductive e.m.f. in the primary windings on breaking the primary current is determined by means of a spark micrometer in parallel with the primary. The variations of this e.m.f. with the current strength and with the number of turns in the secondary are determined. The influences of the primary current strength, of the capacity of the condenser, and of the number of turns in the secondary windings on the spark-length and also on the nature of the spark are given in tabular form in the paper.

A Carpentier coil to give a 45 cm. spark has 153,000 turns and a resistance 50,000 ohms, while one constructed to the author's designs to give 100 cm. spark has 86,000 turns and a resistance of 40,000 ohms. [See also Abstract No. 1717 (1901).] J. B. H.

1942. *Mercury Vacuum Lamps for Spectroscopic Work.* **O. Lummer.** (Zeitschr. Instrumentenk. 21. pp. 201–204, July, 1901.)—The author gives details as to his method of constructing mercury lamps, which were first described by Arons (Wied. Ann. 47. p. 767, 1892, and 58. p. 73, 1896). The lamp is intended for use in spectroscopic work, and for producing monochromatic light of considerable intensity. Arons' form was liable to burst if large currents were used; and though, by immersing it in water, this could be avoided, yet the mercury vapour condensed on the walls of the tube, and so dimmed the light. The author's form is shown in the accompanying diagram. The light passes between the mercury electrodes *c* and *d*, and the lamp is immersed in flowing water, the ends *a* and *b* remaining exposed. The tube *ab* is of frosted glass, except over the portion *a*, which is clear. The light is observed either through the end *a* or *b*. In this way the con-



densed mercury vapour on the walls of *ab* does not interfere with the emission of the light. The reservoir *o* is intended to collect some of the condensed vapour, and to assist in regulating the quantity of mercury. Contacts are made by the mercury cups *m* and *p*. During the act of exhaustion, the tube *b* should be first held in a vertical and then in a horizontal position, in order to prevent the mercury from occluding gases on the walls of the tube. Various details are given as to the mounting of the lamp as a commercial article. It is supplied by Muencke, of Berlin. A lamp that has been properly exhausted works well for years, and the light is almost entirely free from flickerings. The author works generally with an arc about 3 cm. long, and has a series resistance of 5 ohms with 16 amperes at 110 volts. Even with this current strength the lamp will burn for a considerable time without danger of bursting. [See also Abstract No. 1470 (1899).] W. H. S.

1943. *Synchronism and Frequency Indication.* **P. M. Lincoln.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 435–450, June and July, 1901.)—A phase meter, which with a slight modification becomes also a frequency teller, is described. These instruments have been used by the Niagara Falls Company for synchronisers and recording tachometers with successful results. The phase meter consists of a fixed coil inside which is placed an armature made

up of two equal coils at right-angles to one another. One alternating p.d. i applied to the terminals of the fixed coil and the other sends equal current through the two equal coils of the armature. The currents in the two arma ture circuits are made to differ in phase by nearly 90 degrees by puttin a non-inductive resistance in series with one of them and an inductive co in series with the other. It is proved that a pointer fixed to the armatur indicates directly on an evenly divided scale the phase difference between th two e.m.f.'s. At Niagara the instrument is mounted on a swivel so that it ca be made to face the particular dynamo that is to be synchronised. The bus bars are connected to the fixed coil and the dynamo to the movable coils When used as a frequency teller the circuit in series with the fixed coil i adjusted to resonance at the standard frequency. A comparatively sma change in the frequency will then introduce a large change in the phas differences and hence the scale of the phase meter can be graduated to rea the frequency accurately. A full and clear mathematical discussion is give of the action of the instrument when subjected to e.m.f.'s following th harmonic law. A. R

1944. *Alternate-current Measurement.* **A. Campbell.** (Inst. Elect Engin., Journ. 30. pp. 889–908; Discussion, pp. 913–926, June, an pp. 1128–1129, Aug., 1901.)—The author describes the measurement o large currents and high pressures by means of transformers, and gives th conditions which the transformers should satisfy. He describes two method of power measurement, using transformers, and a modification of the three voltmeter method; next comes a method of measuring phase-difference close to 180°, and a description of a thermal ammeter using an aneroi chamber. He then deals fully with the testing of meters, on non-inductive inductive, and fictitious loads. The third part of the paper deals wit thermopile methods, and a method of obtaining steady currents an voltages, by making use of the different temperature coefficients of nicke and manganin. Curves are drawn for wires between the currents as abscissa and the pressures as ordinates, and wires are selected of the two materials s that the curves are parallel over a portion of their length; the vertica distance between them then represents a constant pressure. If a Wheatston bridge be made up of two nickel and two manganin wires in opposite arms and a variable current sent through two opposite points, a constant voltag is obtained at the other opposite points. Finally two null methods o measuring currents are described, making use of this Wheatstone bridg arrangement.

Discussion.—**C. V. Drysdale** pointed out various sources of error in th author's methods, more particularly in the use of transformers, and advocate the use of dynamometer wattmeters. **H. L. Callendar** described therma methods of measurement and of obtaining constant current similar t Campbell's. G. H. B

1945. *Earth Currents.* **Foerster.** (Elektrotechn. Zeitschr. 22. pp. 331–333 April 11, 1901. Paper read before the Elektrotechn. Verein, Feb. 26, 1901.)— The speaker summarised the results of the German Committee on eart currents, formed in 1881, whose material was collected from 1882 to 189 and has since been sifted and worked out by Weinstein. The lines used fo the investigation were one extending south from Berlin to Dresden, an another running east from Berlin to Thorn. It was found at once that eart currents influence the magnetometer just as a current does in an ordinar

galvanometer. The strictly contemporary character of earth-current and magnetic disturbances was so marked that the difference of longitude between Berlin and Wilhelmshafen could be determined within a second by observations of the epoch of a magnetic and an earth-current disturbance respectively. The next question at issue is whether the earth-current generates the magnetic disturbance or the magnetic disturbance induces the earth current. The decision in favour of the former alternative is brought by the fact that the rate of change of the magnetic force does not influence the intensity of the earth current. The speaker proposed a scheme of international earth-current observations. E. E. F.

1946. *Physical Decomposition of the Earth's Permanent Magnetic Field. Part II. The Composition and Characteristics of the Uniform Magnetic Field.* **L. A. Bauer.** (Terrestrial Magnetism, 6. pp. 13–26, May, 1901.)—By the uniform magnetic field of the earth the author means that portion of the earth's permanent magnetic field which can be referred to a uniform homogeneous magnetisation about a single axis (the magnetic axis). In the present paper the author investigates the question as to whether the same value is obtained for the uniform field if the regions from which the magnetic elements employed in the calculation are obtained, are varied. He concludes that: (1) The inclination of the magnetic axis to the axis of rotation is greater for parallels in the Southern Hemisphere than in the Northern Hemisphere. Between the parallels 60° N. and 10° S. the inclination is practically constant, while for parallels to the south of 10° S. the inclination increases at the rate of 0·26° per degree of latitude. (2) The meridional plane in which the axis of uniform magnetisation lies shifts its position almost uniformly to the eastward as we go from the north towards the south. The amount of motion on longitude is on the average 0·5° per degree of latitude. (3) The value of the magnetic moment is a maximum for the equatorial belt and decreases steadily in both hemispheres with departure from the belt. The author puts forward the view that the cause of the displacement for different portions of the earth's surface is the electric currents induced in the earth owing to the fact that it does not rotate about its magnetic axis. W. W.

1947. *Comparison of Magnetometers.* **L. A. Bauer.** (Terrestrial Magnetism, 6. pp. 31–41, May, 1901. Basis of a paper prepared for the Paris Intern. Meteorological Conference, 1900.)—The author has compared a set of the U.S. Coast and Geodetic Survey instruments with those in use in a number of European observatories. The H comparisons were vitiated by the variations in length and shape of a wooden deflection bar owing to changes in the climatic conditions. A comparison of the results for declination and dip with the sets of measurements made by other observers indicates that we are far from possessing sufficient accurate information as to the differences between the standard instruments in use in the various observatories. W. W.

MEDICAL ELECTRICITY.

1948. *Electrical Resistance of the Human Body.* **W. L. Hooper.** (Elect. Rev. N.Y. 38. p. 821, June 29, 1901. Hand-to-hand resistances were measured either with a Wheatstone bridge and one cell or with volt- and ampere-meters and accumulators giving up to 125 volts. The resistances observed varied between 20,000 and 40,000 ohms in the first case, and only between

1,000 and 2,000 ohms in the second. It was not a case of tighter gripping with the higher potential, but there seemed to be increased action of the sweating glands. When very rapid determinations were made with another apparatus comprising condensers, the resistances were higher during the first 0·01 or 0·02 second when the glands had not had time to act than afterwards, but the high values of the bridge method were not obtained and they should not be relied upon. H. B.

REFERENCES.

1949. *Propagation of Electric Force.* **G. Platner.** (Elektrochem. Zeitschr. 7 pp. 241–250, Feb., 1901.)—Maxwell's theory is preferred to the later electron theory and is then discussed as to its suitability for explaining electric and especially electrolytic phenomena. G. E. A.

1950. *Anticoherers.* **A. Neugschwender.** (Phys. Zeitschr. 2. pp. 550–552 June 15, 1901.) **E. Marx.** (Phys. Zeitschr. 2. pp. 574–575, June 29, 1901.)—A controversy on the action of anticoherers. J. E.-M.

1951. *Tesla Discharge from Points.* **K. v. Wesendonck.** (Phys. Zeitschr. 2 pp. 529–530, June 8, 1901.)—A further note upon the author's experiments as to high-frequency electric oscillations favouring a positive or a negative discharge from points under various conditions. E. H. B.

1952. *Influence of Electrode Surface on Discharge of Electricity.* **K. v. Wesendonck.** (Phys. Zeitschr. 2. pp. 514–518, June 1, 1901.)—In dealing with ionised gases metallic electrodes are used to test their various electrical properties. The present paper is an investigation as to how the state of the surface of the electrodes may influence the observations so obtained. R. S. W.

1953. *Laws of Vibration of a Linear Resonator in a Field of Steady Radiation.* **M. Planck.** (Phys. Zeitschr. 2. pp. 530–534, June 8, 1901.)—A mathematical treatment of the problems involved in the absorption and emission of energy by particles exposed to steady radiation as, for example, from the walls of a chamber maintained at the same temperature. The particles in question are regarded as linear resonators, and the theories of Hertz and others are applied to the case. E. H. B.

1954. *Electric Discharge in a Gaseous Mixture.* **W. Heuse.** (Ann. d. Physik 5. 3. pp. 670–677, June, 1901.)—A paper on the same lines as that referred to in Abstract No. 1073 (1900).

1955. *Standard Hysteresis Tests for Iron.* (Elektrotechn. Zeitschr. 22. p. 517 June 27, 1901.)—The regulations of the Verband Deutscher Elektrotechniker with regard to the testing of the magnetic properties of sheet iron are here given. An interesting discussion, which is reported in the Elektrotechn. Zeitschr. pp. 766–768, Sept. 12, 1901, took place at the meeting of the Verein at Dresden, where the regulations were considered and adopted. W. H. S.

1956. *Currents and Potentials on Submarine Cables for Sine E.M.F.'s.* **A. C. Crehore.** (Phys. Rev. 12. pp. 340–352, June, 1901.)—This valuable paper treats mathematically the case of a submarine cable with condensers at the ends under the action of a sine E.M.F.; thus differing radically from Kelvin's original work on the cable which applied to a constant E.M.F. only. The problem is freely illustrated by numerical examples and eleven diagrams, eight of which show potential and current curves for various cases. E. H. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1957. *Capillary Constants of Organic Liquids.* **P. A. Guye** and **A. Baud.** (Comptes Rendus, 132. pp. 1481–1484, June 17, and 1553–1555, June 24, 1901.)—Measurements of the molecular state of liquids by the method of Eötvös-Ramsay-Shields.

According to the results communicated in the first note phenetol, anisol, ethyl acetate, nitrobenzene, and benzonitrile are non-associating liquids, while metacresol appears to associate as the temperature rises. The latter conclusion is founded on the following results :—

Temp. Interval.	Value of K.
9·0 — 55·4	2·05
55·4 — 98·7	1·55
98·7 — 153·1	1·89

The results communicated in the second note indicate that the *oximes* and *urethanes* must be classed with the alcohols, acids, ketones, and aliphatic nitriles as associating liquids. F. G. D.

1958. *Relation between Boiling-point and Density of Organic Liquids.* **G. G. Longinescu.** (Annal. Scientifiques de l'Univ. de Jassy, 1. pp. 359–370, 1901.)—For compounds of carbon and hydrogen, with or without oxygen, which contain the same number of atoms in the molecule, the absolute boiling-points are proportional to the molecular weights. In the general case, however, the relation is not so simple, being expressed by the equation : $T/T' = M/M' \cdot N/N' \cdot \sqrt{n/n'}$, where T and T′ represent the absolute boiling-points of two organic compounds, M and M′ their molecular weights, N and N′ the respective number of molecules contained in a unit of volume, and n and n' the numbers of atoms in the two molecules. These relations are upheld by the constants of a large number of compounds. T. H. P.

1959. *Catalysis of Detonating Gas by Colloidal Platinum.* **C. Ernst.** (Zeitschr. Phys. Chem. 37. pp. 448–484, June 18, 1901.)—Results are given of a number of measurements of the velocity with which water is produced from a mixture of two volumes of hydrogen and one of oxygen by the action of colloidal platinum solution. The apparatus used is described, and also a method of quickly and completely saturating the small quantity of solution with the gas. It is found that colloidal platinum is capable of causing the formation of a million times its own quantity of water without losing its activity. No ozone or hydrogen peroxide occurs in the products of the action. The amount of gas acted on per unit of time is directly proportional to the absolute quantity of platinum present. With detonating gas itself the catalysis procceds with a velocity proportional to the concentration of the gas, while in any mixture of hydrogen and oxygen the reaction goes on as if the gas in excess were a mere diluent. The temperature coefficient of the velocity of the reaction is very small, and becomes negative at high temperatures. The retarding or accelerating actions of certain substances on the reaction seems to run parallel to the similar actions of these substances on the catalysis of hydrogen peroxide by colloidal platinum. T. H. P.

1960. *Semi-Permeable Membranes.* **G. Flusin.** (Comptes Rendus, 132. pp. 1110–1112, May 6, 1901.)—Hitherto more attention has been paid to the measurement of osmotic pressure than to the velocity of osmosis. The author looks for relations between those two quantities. The best results were obtained with Pfeffer's method of producing a membrane precipitated upon the internal wall of the porous vessel, the successes being 10 per cent. To measure the rate of osmose, the manometer was replaced by a graduated horizontal tube, and the rate of displacement of the meniscus was found to be constant for twenty-four hours. The rate of osmosis is not, like the osmotic pressure, independent of the area or of the thickness of the membrane. It varies a good deal with the vessel employed. But if, for different vessels, the rates of osmosis V and V′ of two solutions of the same concentration are taken at the same temperature, it is found that V/V′ is constant and equal to the ratio P/P′ of the two corresponding osmotic pressures. The experiments were made on solutions of glucose, saccharose, antipyrine, and urea. The last substance showed irregularities, but these are due to the fact that a cupric ferrocyanide membrane is permeable to urea. E. E. F.

1961. *Diffusion.* **H. T. Brown.** (Nature, 64. pp. 171–174, June 13, and pp. 193–195, June 20, 1901. Discourse delivered at the Royal Institution, March 22.)—Although the views of Boussingault, according to which the carbonic acid of the air gains access to leaves not through the stomates or minute openings in the cuticle and epidermis but through the continuous substance of these latter, have been shown to be erroneous; yet on applying Loschmidt's absolute values of diffusivity of one gas into another to the passage of the extremely dilute carbon dioxide of the air into the leaf stomates, it is found that free diffusion is apparently able to account for only a portion of the gas known to enter the leaf, unless improbable assumptions are made as to the low proportion of carbon dioxide present immediately under the apertures. By experimenting with a series of exactly similar flasks, partially filled with caustic soda so as to produce a steady flow of atmospheric carbon dioxide down their necks, each having its mouth obstructed with a thin disc of metal or celluloid pierced with a single hole of definite size, the author finds that the amounts of carbon dioxide diffusing down the necks of the flasks in a given time are proportional to the diameters of the disc apertures. This diameter law also holds, under certain conditions, for the amount of absorption by, or evaporation from, plain, circular liquid surfaces; if the air above such surfaces is in slight movement the absorption or evaporation is proportional to the area of the disc, but the smaller the discs and the stiller the air the more nearly does proportionality to the diameters hold. The author goes on to consider the case of a disc with a number of holes in it; if the holes are suitably arranged little or no obstruction is offered to the diffusive flow, although the aggregate area of the holes represents but a small fraction of the area of the disc. Experimental confirmation of this is obtained by allowing copper sulphate solution to diffuse down two separate columns of gelatine, one unobstructed while the other has a perforated celluloid film between it and the liquid, or by making a similar experiment with a perforated and a non-perforated septum luted on to short tubes containing caustic soda solution; in one of the author's trials a larger quantity of carbon dioxide is found to diffuse through a perforated disc than through an aperture of area equal to the disc. The author draws an analogy between the absorbing disc or perforation of these diffusion experiments and an electrified disc embedded flush in a wide non-conducting

m; in the latter case the surfaces of equal electric potential in the air above the disc will be represented by a series of hemi-spheroids which in any vertical section passing through the centre of the disc will give a series of ellipses having their common foci in the edges of the disc, the lines or tubes of force consisting of a series of hyperbolæ, also having their foci in the edges of the disc. Such an analogy gives a reasonable and consistent explanation of all the phenomena of diffusion into and through apertures, besides completely explaining the "diameter law" and making possible the accurate prediction of the amount of gas, vapour, or solute passing under given conditions. The existence of zones of equal density in the neighbourhood of an aperture through which diffusion is going on may be shown by means of a rectangular cell divided horizontally by a thin plate of celluloid with a circular hole punched in it, the lower half of the cell being filled with a solution of gelatine containing a little barium chloride and the upper half with sodium sulpnate solution; if the relative strengths of the two solutions are so adjusted that the two salts, diffusing in opposite directions, meet in the gelatine, barium sulphate is precipitated at the surfaces of contact of the two streams, the result being a slowly growing, spheroidal mass of precipitate starting from the aperture and resembling in shape the head of an inverted mushroom. By making the diffusion of the sodium sulphate intermittent, or by alternating the diffusion of a sulphate with that of a chromate, well-marked spheroidal zonings are obtained in the precipitate. In a similar manner the form of the zones of equal intensity for diffusion through several apertures or between two parallel plates may be found. Experiment shows that the most efficient arrangement of very small apertures is to have them about 8 or 10 diameters apart, for in this case interference with each other practically ceases; this is generally about the distance apart of the stomates on the underside of most leaves. To account for the passage through the stomates of the quantity of carbon dioxide absorbed by a leaf it is only necessary for the carbon dioxide content of the air just within the leaf to be kept down to 2·8 parts per 10,000, when that of the outer air is 3 parts per 10,000. T. H. P.

1962. *Chemical Reactions in Dissolved or Gaseous Systems.* **Ponsot.** (Comptes Rendus, 132. pp. 1551–1553, June 24; 1901.)—Imagine a solution in which a reversible chemical reaction can occur. Denote the systems on each side of the equation by 1 and 2. Suppose that at constant temperature and pressure, 2 increases indefinitely at the expense of 1 as the dilution increases. Let e denote mass of the solvent and Φ total internal thermodynamic potential. Consider a system not in equilibrium. If 2 tend to *increase*, $\frac{d\Phi}{dm}$ is negative, n denoting the molecular concentration of one of the components of system 2. Equilibrium, corresponding to $\frac{d\Phi}{dm}=0$, will be established by diminishing e. Hence $\frac{\partial}{\partial e}\frac{d\Phi}{dm}$ is negative. Similarly if 2 tends to *diminish*, it can be shown that $\frac{\partial}{\partial e}\frac{d\Phi}{dm}$ is also negative. Hence with the given assumptions it is always negative. But—

$$\frac{\partial}{\partial e}\frac{d\Phi}{dm}=\frac{d}{dm}\frac{\partial\Phi}{\partial e}=v\frac{df}{dm}$$

when f = vapour-pressure of solvent and v the corresponding specific volume. Hence "the formation of the system which tends to exist exclu-

sively at infinite dilution and which decreases with decreasing dilution diminishes the vapour-pressure of the solvent, while the formation of the opposite system increases it."

The remainder of the paper is connected with the following theorem: Let V_1 be the volume corresponding to the existence of system 1 alone, V_2 the corresponding volume for 2 at pressure P. Then $P(V_2 - V_1)$ is positive for all values of P. This theorem applies also to solutions, understanding then by P osmotic pressure. F. G. D.

1963. *Surface-tension and Solubility.* **G. A. Hulett.** (Zeitschr. Phys. Chem. 37. pp. 385–406, June 18, 1901.)—An aqueous solution of gypsum, saturated at 25° in contact with the coarsely powdered mineral after washing away all small particles, contained 2·085 g. $CaSO_4$ or 2·631 g. $CaSO_4 . 2H_2O$, or 15·330 millimols. per litre, and had a specific conductivity 0·002206 in reciprocal ohm-centimetre units. The equivalent conductivity at infinite dilution was found to be 125 at 25°, and the concentration of the other solutions could then be determined from their conductivity. By grinding the gypsum very finely a solution was obtained of specific conductivity 0·002520, which therefore contained 2·476 g. $CaSO_4$ or 3·1315 g. $CaSO_4 . 2H_2O$ or 18·204 millimols. per litre, the solubility being increased by 19 per cent. by the finer division of the gypsum. As in other cases the larger particles grow at the expense of the smaller ones, and after a few days the solubility decreases to that of the coarsely divided mineral. On the other hand, continual stirring tends to grind up the coarser particles of gypsum, and the solubility then tends towards that of the finely divided mineral. The diameters of the smallest particles in contact with the solution were found to be about 2·0 μ and 0·3 μ respectively in the case of the coarse and the fine mineral.

In the case of barium sulphate equilibrium occurs when the solution contains 2·29 millimols. per litre, and the smallest particles have a diameter of about 1·8 μ. By grinding, the size of the smallest particles is reduced to 0·1 μ, and the solubility rises to 4·15 millimols. per litre. By grinding with quartz a finer subdivision results and the solubility is further increased by about 20 per cent.

In the case of mercuric oxide the normal solubility is 50 mg. = 0·231 millimols. per litre; by grinding this is increased to 150 mg. = 0·694 millimols. per litre. T. M. L.

1964. *Phosphorus Oxychloride as a Solvent in Cryoscopy.* **G. Oddo.** (Accad. Lincei, Atti, 10. pp. 452–458, June 1, 1901.)—The molecular depression of the freezing-point of phosphorus oxychloride is found by measurements with solutions of toluene, of sulphur monochloride and of bromine to have the value 69; tetrachloromethane gives a slightly higher number. In dilute solution in phosphorus oxychloride, aniline hydrochloride, pyridine hydrochloride, ferric chloride, platinum tetrachloride and gold trichloride all undergo ionisation, giving approximately half the calculated molecular weights. T. H. P.

1965. *E.M.F.'s between Metals in Fused Salts.* **V. Buscemi.** (N. Cimento, 1. pp. 201–206, 1901. Summarised from Atti dell' Accad. Gioenia in Catania, vol. 12, ser. 4.)—A cell composed of the series $Zn—ZnCl_2—SnCl_2—Sn$ has an e.m.f. of 0·36 volt. This e.m.f. is independent of the temperature. In cooling from 250° to 240° there is a great increase of resistance owing to the solidification of the chlorides, but the e.m.f. remains practically the same

According to Helmholtz, the e.m.f. of a cell diminishes with rising temperature when the chemical heat is greater than the voltaic heat and *vice versâ*. When the two heats are the same, the e.m.f. is independent of the temperature. This happens in the cell described. The author also measured the e.m.f. between two zinc electrodes immersed in $ZnCl_2$ at two different temperatures. The difference in temperature being θ he found the e.m.f. to be given by $E = 0{\cdot}000151 \times \theta$ volts. Poincaré gives $0{\cdot}00013 \times \theta$. E. F. F.

1966. *Validity of the Law of Mass Action for Strong Electrolytes.* **H. v. Steinwehr.** (Zeitschr. Elektrochem. 7. pp. 685–686; Discussion, pp. 686–687, June 6, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Freiburg, April 19, 1901.)—By the dilution of a solution of a strong electrolyte an energy-change is produced, due not only to the alteration of osmotic pressure but partly also to change in the internal pressure of the solution. The dissociation is accompanied by a diminution of volume which is conditioned by the increase of internal pressure. In the equation for the dissociation isotherms, it is necessary to take account of this influence of the pressure on the energy, and the amount of such influence can be approximately calculated from the change produced in the rate of inversion of cane-sugar by acetic acid when potassium or sodium chloride is added; the researches of Arrhenius on this point show that an increase takes place in the dissociation of the acetic acid and a variation in the constant for different dilutions. Since also the influence of the external pressure on the dissociation constant has been experimentally determined by Fanjung, the change of the internal pressure and its influence on the dissociation constant can be calculated. Introducing this correction, it is found that the dissociation constant of acetic acid in presence of potassium chloride or of sodium chloride shows but slight variations. T. H. P.

1967. *Migration-velocity of Ions in Dilute Solution.* **H. Jahn.** (Zeitschr. Phys. Chem. 37. pp. 673–712, July 12, 1901.)—The following are the results of a redetermination of the transportation values of the kathion in the case of dilute solution of the most important salts and acids. The values given by other observers are also shown (H = Hittorf, B = Bein, K = Kuschel).

HCl	0·826	0·786 H.; 0·833 B.
HNO_3	0·830	0·855 Wiedemann
KCl	0·497	0·495 H.; 0·495 B; 0·497 K.
KBr	0·496	
NaCl	0·396	0·387 H.; 0·385 B.
NaBr	0·395	
LiCl	0·330	0·326 K.; 0·376 B.
$BaCl_2$	0·447	0·443 B.
$CdCl_2$	0·430	
$CdBr_2$	0·430	
CdI_2	0·443	
$AgNO_3$	0·471	0·474 H.; 0·475 B.
$CuSO_4$	0·375	0·362 H.; 0·357 B.

In most cases these values are independent of the concentration up to N/30; HNO_3 gives a constant value to N/4, but the value for LiCl decreases to 0·300 at N/4; $CdCl_2$ and $CdBr_2$ give constant values to N/16, but the value for $CdBr_2$ decreases to 0·350 for N/4 and 0·218 for N/2 solutions; CdI_2 gives constant

values to about N/80, but the values then decrease to 0·381 for N/30, 0·223 for N/12, and 0·003 for N/4 solutions; the value for $CdSO_4$ is constant to N/30, but decreases to 0·254 at N. The values for $CuSO_4$ are very constant to N/16, but decrease to 0·328 in N/4 solution. T. M. L.

1968. *Degree of Ionisation of Strong Electrolytes.* **O. Sackur.** (Zeitschr. Elektrochem. 7. pp. 784–787, July 18, 1901.)—Jahn has explained the deviations of strong electrolytes from Ostwald's law by assuming that the law of mass-action applies for ionisation as well as for the dissociation of gases, but that the migration-velocities of the ions are influenced by the presence in the solution of the strong electrolyte; thus he supposes the mobility of the ions to be 6 per cent. greater in N/100 HCl than in 600 HCl. It is now shown that even if this is true the law of mass-action must break down in the case of mixtures, for the conductivity of mixtures of KCl and HCl, and of KCl and NaCl cannot be calculated from the law of mass-action even when Jahn's values for the migration velocities are assumed. The differences between the observed and calculated values usually amount to 2 or 3 per cent. The views of Hausrath, that the partial pressure of the unionised molecules is increased by the ions in the solution, and of Steinwehr, that the internal pressure of the water is altered by the electrolyte, are also criticised. [See also Abstract No. 1742 (1901).] T. M. L.

1969. *Electrical Test for Small Quantities of Electrolytes whose Ions have different Migration-Velocities.* **M. Oker-Blom.** (Zeitschr. Phys. Chem. 37. pp. 665–672, July 12, 1901.)—Two calomel electrodes, containing 0·01 KCl and 0·00001 KCl, were connected by a strip of filter-paper moistened with an electrolytic solution; a marked e.m.f. was produced, amounting to about 0·1 volt in the case of normal hydrochloric and lactic acids and about 0·04 volt in the case of hydrogen potassium phosphate. By this method a fraction of a milligramme of an electrolyte can be detected, and the method is especially adapted to physiological work. T. M. L.

1970. *Contact E.M.F.'s and the Ionic Theory.* **E. Rothé.** (Comptes Rendus, 132. pp. 1478–1481, June 17, 1901.)—The author has employed a Lippman capillary electrometer, using as liquids dilute sulphuric and dilute hydrochloric acid, keeping the liquid in the neighbourhood of the large mercury surface saturated with mercurous sulphate and mercurous chloride respectively. Varying the strength of the acid solution employed, he has determined the compensating e.m.f. required for maximum surface tension. He finds for dilute solutions a "very satisfactory" agreement between the experimental results and the values calculated on the basis of the Nernst van't Hoff-Arrhenius theory. F. G. D.

1971. *Liquid Cells.* **O. Sackur.** (Zeitschr. Elektrochem. 7. pp. 781–784, July 18, 1901.)—In the combination—

$$Ag \mid AgCl \mid KCl(c_1) + KNO_3(\gamma) \mid KCl(c_2) + KNO_3(\gamma) \mid AgCl \mid Ag$$

$$+ Ag \mid AgCl \mid LiCl(c_2) + LiNO_3(\gamma) \mid LiCl(c_1) + LiNO_3(\gamma) \mid AgCl \mid Ag,$$

all the e.m.f.'s are balanced except those at the boundaries of two lithium and of the two potassium solutions; as the migration velocities of the $\overset{+}{K}$ and $\overset{-}{Cl}$ ions are nearly equal the e.m.f. between the two potassium solutions is negligible and the e.m.f. of the combination is simply that which is set up between th

two lithium solutions, $LiCl(c_1)$ and $LiNO_3(\gamma)$ and $LiCl(c_2) + LiNO_3(\gamma)$. Abegg and Bose (Zeitschr. Phys. Chem. 30, 545) have given for the e.m.f. between two solutions of this kind a general formula of which Nernst's formula is a particular case ($\gamma = 0$), and this formula has now been tested by means of combinations of the type given above in the case of dilute solutions of lithium chloride containing equal amounts of lithium nitrate, and dilute solutions of hydrochloric acid containing equal amounts of nitric acid. The concentration of the more dilute chloride solution was in all cases N/500, whilst the less dilute chloride solution varied from N/25 to N/100 in the different experiments; the concentration of the nitrate in the solutions varied from N/25 to N/200. The observed e.m.f. varied in the case of the lithium solutions from 0·0024 to 0·0128 volt and in the case of the acid solutions from 0·0038 to 0·0296 volt; the values calculated from the formula of Abegg and Bose agree very closely with the observed values, and in only three cases was a difference greater than 0·001 volt observed. T. M. L.

1972. *Action of Non-electrolytes on the Hydrolysis of Ethyl Acetate.* **C. Kullgren.** (Zeitschr. Phys. Chem. 37. pp. 613–622, June 28, 1901.)—The reaction-constant for the hydrolysis of N/40 ethyl acetate by N/40 sodium hydroxide at 20·7° is 4·04. It is reduced to 3·16 by the addition of 5·3 gm. cane-sugar per litre (= N/40), to 1·96 by the addition of 21·1 gm. per litre (= N/10) and to 0·38 by the addition of 158·7 gm. per litre (= 3/4N): this very marked effect is probably due to the partial neutralisation of the sodium hydroxide with formation of a saccharate. The addition of glycerol produces a similar, though smaller effect, the constant being reduced to 2·74 by the addition of 162·3 gm. of glycerol per litre (= 2·3N), and to 1·64 by the addition of 325·7 gm. per litre (= 4·6N). The addition of methyl alcohol, ethyl alcohol, and acetone also causes a diminution of the reaction-constant, but the effect is not very great except when these substances are added in large excess; it is probable that they act chiefly by altering the medium in which the interaction takes place, and not by combining with the base.

The addition of non-electrolytes causes a diminution in the conductivity of N/40 sodium hydroxide, which is comparable with the diminution of the reaction-constants. T. M. L.

1973. *Electrochemical Action.* **C. J. Reed.** (Frank. Inst., Journ. 151. pp. 369–393, May; 401–413, June; and 152. pp. 46–58, July, 1901.)—General considerations of voltaic action and electrolysis. The author upholds the theory according to which the ions receive induced charges when a p.d. is applied to the electrodes, and separate only when this p.d. exceeds a certain value. He suggests that concentration changes are due to the rotation of the molecules. W. R. C.

1974. *Accumulator Short-Circuit Diagrams.* **M. U. Schoop.** (Centralblatt für Accumulatoren, 2. pp. 157–160, June 1, 1901.)—The discharge of an accumulator is studied by taking the e.m.f. on open circuit as the cell is gradually short-circuited. The corresponding current is also observed, and the results are plotted to obtain a "short-circuit diagram." The examples given show that the e.m.f. is a simple linear function of the current strength. The charge at each plate is also observed by the help of an intermediate electrode of mercurous sulphate. The fall of pressure is by this means shown to be greater at the lead than at the peroxide plate. W. W. H. G.

1975. *Theory of Accumulators.* **E. Abel.** (Zeitschr. Elektrochem. 7. pp. 731–733, June 27, 1901.)—Of the two views as to the osmotic action of an accumulator, that of Liebenow, which regards the peroxide electrode as reversible with respect to PbO_2 ions, is usually considered the simpler and more readily expressed by exact formulæ. The author shows, however, that Le Blanc's older view of the process is equally satisfactory and leads to the formula—

$$E = \frac{RT}{2} ln \frac{[Pb''''']_1}{[Pb''''']_2}$$

for the e.m.f. of the cell, $[Pb''''']_1$ being the concentration of the Pb'''' ions at the positive electrode, and $[Pb''''']_2$ the concentration of the Pb'''' ions in equilibrium with Pb'' ions in the presence of lead. N. L.

1976. *E.M.F. due to Magnetisation of an Electrode.* **R. Paillot.** (Comptes Rendus, 132. pp. 1318–1320, June 3, 1901.)—This is a continuation of the researches referred to in Abstract No. 668 (1901). The e.m.f. of soft iron increases with the temperature, and its variation with the temperature is greater the stronger the field. The e.m.f. of bismuth falls but very slowly when the temperature is raised. A. D.

1977. *Effect of Gravity and Pressure on Electrolytic Action.* **R. R. Ramsey.** (Phys. Rev. 13. pp. 1–30, July, 1901.)—Owing to the difference in weight of the ions and their different migration velocities, a small e.m.f. should be set up between two metallic electrodes at different heights in an electrolytic solution. In order to observe this experimentally a tube containing two electrodes of zinc or cadmium amalgam, was filled with zinc or cadmium sulphate and connected in series with a sensitive galvanometer; on raising the tube from a horizontal to a vertical position a deflection of the galvanometer was produced; for purposes of observation the tube was reversed in unison with the swing of the galvanometer until a maximum amplitude of oscillation was produced; from the observed amplitude and the constants of the galvanometer the e.m.f. in the tube could be determined. In the case of zinc electrodes in 10 per cent. zinc sulphate solution the calculated e.m.f. was $2{\cdot}4 \times 10^{-8}$ volts per cm. of height between the electrodes; the values of the e.m.f. observed on six different days were 6·5, 3·9, 2·3, 3·0, 3·4, and $3{\cdot}1 \times 10^{-8}$ volts, the mean of the last five observations being $3{\cdot}1 \times 10^{-8}$ volts. Similar results were obtained with cadmium electrodes in a solution of cadmium sulphate.

The effect of pressure, applied by means of a piesometer filled with kerosene, on a number of cells was also determined, with the following results:—

	E.M.F.	Temp.	Increase of e.m.f. per atmo. (to 100 atmo.)	Increase of e.m.f. per atmo. (from 100 to 300 atmo.)
Cadmium.....	1·019	19°	$7{\cdot}6 \times 10^{-6}$ volts	$7{\cdot}6 \times 10^{-6}$ volts
Clark	1·440	16·6	11·6	11·6
Carhart-Clark.....	1·443	16·3	13·1	13·1
One-volt calomel ...	0·996	15	3	0·98
Saturated calomel ...	0·805	17	2·8	1·63
Copper sulphate.....	1·078	17	—1 (?)	—1 (?)
AgCl (white)	1·076	18	25·7	15
AgCl (black)	1·164	15·6	—	—13

The pressure-effect is exactly linear in the case of the Cadmium, Clark, and Carhart-Clark cells. T. M. L.

1978. *Solution for Copper Voltameter.* **W. K Shepard.** (Amer. Journ. Sci. 12. pp. 49–56, July, 1901.)—The author used a solution of copper sulphate made as follows :—A saturated solution of copper sulphate was boiled for a short time to expel the air and then kept at 100° C. for about an hour in contact with metallic copper in order to neutralise the solution. The density was then about 1·20. A very small amount of NH_4Cl was added, about 0·05 per cent.

This solution was compared with those due to Grey (Phil. Mag., 1886), and Oettel (Chemische Zeitung, 1893). The former can be used up to a current density of 0·2 amp. per sq. cm., and the same limit was here found for the latter. No oxidation was found with the present solution up to 0·07 amp. per sq. cm. (the highest attempted), and the result was found to be independent of the current density. If this is 0·05 amp. or more per sq. cm. the solution heats a little, and should be warmed to 35° or 40° C. before passing the current; the result is then satisfactory. The solution may be used a large number of times. W. R. C.

1979. *Electrochemical Production of Alkali Ferrates.* **W. Pick.** (Zeitschr Elektrochem. 7. pp. 713–724, June 20, 1901.)—This paper contains an account of experiments in extension of those of F. Haber [Abstract No. 1364 (1901)] on the electrolysis of caustic alkalis between iron electrodes. All varieties of iron undergo anodic polarisation in concentrated alkaline solutions and furnish a variable quantity of alkali ferrate, the largest yield being given by cast iron and the least by wrought iron; steel occupies an intermediate position. Pieces of steel or wrought iron which at first yield no ferrate may always be made to do so by a few seconds' alternate anodic and kathodic polarisation, or by feeble anodic polarisation for a long time in strong alkali. Iron from which ferrate has been produced acquires a dark colour, assumes a passive condition, and resists the rusting action of the air. The yield of ferrate is greater from caustic soda than from caustic potash, and increases with the concentration. Thus, with a current density of 0·1 ampere per sq. dm. in caustic soda, cast iron gave 47 per cent., steel 26 per cent., and wrought iron 14 per cent. of ferrate, whilst in potash the corresponding figures were 37, 13, and 2 per cent. A rise of temperature favours the production of ferrate, the yield in one experiment being almost nil at 0°, 16 per cent. at 30°, and 80–100 per cent. at 70°. The yields of ferrate and of oxygen together amount to 100 per cent.; hence *ferrites* are not formed by the primary electrochemical reaction. N. L.

1980. *Electrochemical Behaviour of Nickel Ammonium Sulphate.* **W. Pfanhauser.** (Zeitschr. Elektrochem. 7. pp. 698–710, June 13, 1901.)—The consistence of electrolytic nickel depends greatly on the chemical composition of the solution from which the metal is deposited, and experience has shown the necessity of using compound salts of nickel rather than simple salts. The present paper describes a large number of experiments on the influence of ammonium sulphate on the electrolysis of nickel sulphate solution. The addition of the former salt causes the formation of the double salt $(NH_4)_2Ni(SO_4)_2 + 6H_2O$ and increases the specific conductivity of the solution. In concentrated solutions the double salt is dissociated into the ions $\overset{+}{NH_4}$ $\overset{+}{NH_4}$ and $\overset{-}{Ni}(\overset{-}{So_4})_2$, whilst in dilute solution it undergoes decomposition into its constituent salts. Hence if the electrolyte is not kept stirred, the double salt diminishes and decomposes at the kathode, whilst at the anode it remains

undecomposed and often crystallises out. Polarisation occurs at the anode in consequence of the oxidation of nickelous to nickelic sulphate ; the latter salt, however, is unstable and is hydrolysed in neutral solution with the formation of a black deposit of the hydroxide $Ni(OH)_3$. In acid solution this is prevented, and oxygen is evolved. With low current-densities the deposition of the metal is wholly a secondary reaction, but with high densities the double salt is used up faster than it can be replaced by diffusion, the concentration diminishes, nickel sulphate is formed by the consequent decomposition of the double salt, and primary deposition of the metal in a black, pulverulent form occurs. N. L.

1981. *Simultaneous Deposition of Iron and Nickel from Mixed Solutions of their Sulphates.* **F. W. Küster.** (Zeitschr. Elektrochem. 7. pp. 688–692, June 6, 1901.)—Under similar conditions, the electro-deposition of nickel from nickel sulphate takes place at a lower potential than that required for the deposition of iron from iron sulphate, whilst iron is more readily deposited than zinc. Nevertheless, according to Toepffer [Abstract No. 1124 (1900)], when a solution containing the sulphates of iron and nickel, or zinc and iron, is electrolysed the less noble metal is obtained in larger quantity. The experiments previously described by the author [Abstract No. 421 (1901)] have been extended with the object of explaining this anomaly which appears to depend on the relation of the velocity of the reaction to chemical resistance. N. L.

1982. *Action of Ammonium Nitrate Solution on an Iron Kathode. A new Ferroso-ferric Oxide.* **A. Kaufmann.** (Zeitschr. Elektrochem. 7. pp. 733–741, June 27, 1901.)—It has been noticed by Haber and Reininger that when a saturated solution of ammonium nitrate is electrolysed between a carbon anode and an iron kathode, using a kathode current density of about 0·02 ampere per sq. dm., a golden yellow ammoniacal solution is obtained which, when boiled, deposits a bluish-black precipitate. The author has investigated this reaction and finds that the yellow solution, which may also be obtained by the action of ammoniacal ammonium nitrate solution on finely divided iron, contains ferrous ammonium nitrate, whilst the black precipitate consists of a new oxide of iron of the composition Fe_8O_{11}. N. L.

1983. *Electrolytic Reduction of Aromatic Nitro-compounds to Amines.* **A. Chilesotti.** (Zeitschr. Elektrochem. 7. pp. 768–773, July 11, 1901.)—The electrolytic reduction of nitro-derivatives to amines is greatly facilitated, according to previous observers, by the presence of small quantities of tin, copper, mercury, or iron salts. The author describes experiments with nitrobenzene and similar compounds which show the great value of this suggestion. It appears that when copper or iron salts are used, the reduction to hydroxylamine derivatives is effected electrolytically with the simultaneous formation of spongy copper or ferrous salts ; the purely chemical action of these latter then completes the reduction to amines. N. L.

REFERENCE.

1984. *Electromotive Behaviour of Substances with Several Degrees of Oxidation.* **E. Abel.** (Zeitschr. Phys. Chem. 37. pp. 623–625, June 28, 1901.)—A criticism of R. Luther's paper [Abstract No. 1356 (1901)]. T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1985. *Condensing Engines for Lighting Stations.* **R. V. Picou.** (Ind. Élect. 10. pp. 269–271, June 25, 1901.)—The advantage of using condensing engines for electric light central stations is largely a question of the period of working under full load, because the cost of condensing may, under certain circumstances, exceed that of the extra fuel required in non-condensing engines. Condensing may answer in an engine which works all day, but might be useless in one working at maximum load for an hour only. The limits of usefulness are fixed by the local conditions determining the period of full load for each unit.

Failing more recent trials the results of experiments made in 1884 with a Corliss engine at Creusot and published by Delafond in the *Annales des Mines*, Sept. and Oct., 1884, are quoted. In these trials the amount of steam used per h.p.-hour (French) was for—

	With Condensation.	Without Condensation
Indicated h.p.	7·58	9·92
Effective „	9·47	11·41

for powers varying from 122 to 240 h.p. (French).

These figures disclose an important relation called the "organic yield," thus:—

$$\frac{7{\cdot}58}{9{\cdot}47} = 0{\cdot}80, \text{ and } \frac{9{\cdot}92}{11{\cdot}41} = 0{\cdot}87.$$

The difference shows the cost (in motive power) of working the air-pump, which in this case was in tandem with the steam cylinder.

With condensers it is usually necessary to lift the requisite water, either first from a well or afterwards to force it through a refrigerator, and the work of the circulating pump must therefore be added. The condensing water amounts to about 200 litres per h.p.-hour, and if we call the lift 10 metres, that means for each h.p.-hour 2,000 kilogrammetres for water lifted or for 150 h.p. 300,000 kilogrammetres or 1·11 h.p. (French). The inefficiency of pumps and loss in transmission of power cause at least 2 h.p. effective to be absorbed.

The comparative economy of steam due to condensation is thus stated :—

	With Condensation.	Without Condensation.
H.P. Indicated	150	150
„ Effective	120	130
„ Disposable	118	
Steam used in kilogrammes per hr....	1137	1488
„ per h.p.-hr. disposable (kg.)	9·63	11·45

Difference in steam used is 1·82 kilog. per h.p.-hr. disposable.

There are, however, additional charges which have to be placed against this economy, such as cost of condenser, pipes and valves, extra foundations, &c. These are taken at 5,500 francs, on which 10 per cent. for interest and sinking fund are charged.

From these figures a commercial equation is found which will give in terms of the value of the fuel the limits of the working period for which condensation will be profitable.

Calling P the price of the fuel per kilogramme, t the annual period of working in hours, and 7·5 the weight of water evaporated per unit of fuel burned, then the cost of surplus steam used in non-condensing engines will be :—

$$\frac{130 \times 1{\cdot}82}{7{\cdot}5} \times P \times t$$

In the other case, with 550 francs as the annual charge due to the condenser, we find—

$$t \times P = \frac{550 \times 7{\cdot}5}{130 \times 1{\cdot}82} = 17{\cdot}43.$$

Whence according to different prices of fuel we have the following values :—

P	t
20 francs per ton (French)	871 hours per annum
25 „ „ „	700 „ „
30 „ „ „	580 „ „

Thus even with dear coal it does not pay to condense if the working load is carried for less than 580 hours per annum, or about 1½ hours per day ; and with coal at 25 francs the limit is 700 hours, or about 2 hours per day.

With independent condensers the conditions are altered to the extent that the difference in amount of steam consumed is 2 kilogs. ; the cost of installation is 16,500 francs, and the annual charge is 1,650 francs : so that $tP = 17{\cdot}60$, from which the following values are deduced :—

P	t
20 francs per ton	2,380 hours annually
25 „ „	1,904 „ „
30 „ „	1,517 „ „

Showing no economy with condensation for a less period than 4 to 6 hours per day according to the price of coal.

Even although non-condensing engines may use 16 to 20 per cent. more steam than condensing engines it does not follow that boilers must be increased in size for them, because that is balanced by the use of hotter feed-water. Non-condensing engines enable feed-water at 100° C. to be used, whereas condensing engines do not supply water hotter than 40° C. The difference in evaporation caused thereby is equal to 15 per cent. increase of heating surface. The condenser being often a cause of stoppage from leakage of air, bad joints, pumps, &c., the simpler non-condensing plant would seem to be the more suitable for electric light station work. Ejector condensers are, however, more simple and less costly, although less efficient, than the others.

F. J. R.

1986. *Steam Turbine.* **J. A. Ewing.** (Electrician, 47. pp. 254–256, June 7, 1901.)—A report on trials of a 500-kw. steam turbo-alternator at the works of the Cambridge Electricity Supply Company. The machine was loaded for the purpose of the tests by allowing current to flow between iron plates in the river Cam, the output being measured by means of a Kelvin watt

balance. The air-pump discharge was measured by means of two calibrated tanks, used alternately.

Number of trial	1	2	3	4	A	B
Output kw.	518	586	273½	160½	535	300
Speed r.p.m.	2,670	2,740	2,630	2,590	2,880	2,800
Air-pump discharge } lbs. per kw.-hour	25·0	24·4	28·3	33 1	25·0	27·6

These figures give most satisfactory evidence that the machine working under the conditions of everyday use, and after having been in everyday use for a year, retains its character as a highly efficient electrical generator. H. R. C.

1987. *Transmission of Heat through Scale-covered Boiler Tubes.* **E. C. Schmidt.** (Railroad Gazette, 33. pp. 408–409, June 14, 1901.)—A number of tests of the relative heat conductivity of clean and scale-covered locomotive boiler tubes (the first of a projected larger series of such tests) have been made by F. L. McCune, under the direction of the Railroad Mechanical Engineering Department of the University of Illinois. The tubes were in all cases 1·75 inches diameter inside, and 2 inches diameter outside—the length of tubes is not stated—and were covered with mud scales or mineral scales of various thicknesses, the average ranging from 0·013 to 0·13 inch, and the quality from "soft, porous" to "hard, dense." Each tube was placed in a cylindrical chamber through which water from a constant-pressure tank was allowed to flow, the temperatures at inlet and outlet being observed. The hot gases were passed through the inside of the tube from a combustion chamber in which was a gas-burner supplied with gas and air under regulated pressure. An average of ten experiments gave a gas consumption of 125·6 cubic feet per hour, and an air consumption of 842 cubic feet per hour—the air having been supplied to the burner at a pressure of 5⅜ inches of water.

The temperature of the combustion chamber at the entrance end of the tube was measured by a copper ball pyrometer, and that of the escaping gases by a thermometer.

The difference between the average temperature of the gases and that of the water averaged 869·3° F., and the number of B.Th.U. transmitted during one hour varied from 24859 to 29792 in the coated tubes, the clean tube having transmitted 29854, so that the amount of the decrease in conductivity due to the scales ranged from 0·21 to 16·73 per cent.

The accumulation of additional results is expected to throw light upon the effects of different sorts of scale, so that some general conclusion may be arrived at as to the relations existing between conductivity and the thickness, hardness, and other physical and chemical qualities of the scale. F. J. R.

1988. *Boiler Tests with Illinois Coals.* **L. P. Breckenridge.** (West. Soc. Engin., Journ. 6. pp. 220–230; Discussion, pp. 230–244, June, 1901.)—This is a record of 150 tests carried out by the Department of Mechanical Engineering at the University of Illinois during the last seven years, principally at the power plants of the University, with some at Champaign and Urbana cities. The results are given in tabular form, along with tables of chemical analyses of 68 specimens of Illinois coals and of 57 different specimens of boiler waters, these analyses having been made under the direction of S. W. Parr at the

Department of Applied Chemistry. The coal supplies were from mines scattered over a large portion of the State. The tests were carried out with different kinds of boilers and boiler settings, divided over 8 different plants, those employed having been Stirling water-tube boiler, 1 setting; National water-tube boiler, 1 setting; Babcock-Wilcox water-tube boiler, 8 settings; horizontal tubular boiler, 10 settings. One Murphy smokeless furnace, one Brightman stoker, two Roney automatic stokers, and one Babcock-Wilcox chain-grate stoker were amongst these settings, the remainder having been arranged for hand-firing. Illustrations showing the construction of several of these boilers and settings are given in the paper. The results are more correctly records of everyday performances of these boilers under ordinary conditions, as they were not special tests made to demonstrate the peculiar merits of any special apparatus. Hence they have a value of their own.

The author maintains that whilst a draught of $\frac{3}{10}$ to $\frac{5}{10}$ inch of water gives excellent results with coals having 60 per cent. of fixed carbon, it is found that for most of the Illinois coals a draught of $\frac{6}{10}$ to 1 inch should be provided in order to obtain the best results. He also advocates larger combustion chambers than are customary, and the construction of firebrick arches to prevent the gases coming in contact with the boiler heating surface before inflammation is complete.

Discussion.—**A. Bement** pointed out that the curve of maximum results showed that the highest efficiency was obtained with an evaporation of 2 to 3·5 lbs. of water per square foot of heating surface, the efficiency falling off when that was increased. He had, however, seen instances of an increase of evaporation up to 10 and 11 lbs. of water per square foot of heating surface with concurrent increase of efficiency. He advocated the employment of gas of standard composition burned with minimum air supply for making reliable tests of boiler efficiency of which none had as yet been made. He showed curves of results from Wm. Kent's "Steam Boiler Economy," and from vol. ii. of Jour. West. Soc. Eng., with others in order to compare their relative efficiencies. **Gasche** advocated the formation of a curve of evaporation for each boiler for a given fuel, according to the plan given by him in a paper to the West. Soc. Eng. in August, 1897. **Rice** showed that the methods of estimating moisture in coal are not reliable, so that it is futile to estimate evaporative performance on a basis of "dry coal." **J. J. Merrill** said that he had discontinued the use of 9 boilers in a plant of 20 boilers formerly all in use, and had obtained a reduction of 75 tons of coal per day for the same boiler load. This result was due to analysing the gases and having intelligent firemen. With a new plant fitted with chain-grate stokers burning 52 lbs. of coal per square foot of grate he had, for the same amount of work, a reduction of 55 tons of coal per day as compared with former plant which had about 30 per cent. more heating surface. **Breckenridge,** in reply, referred to the curves of calculated efficiencies for different rates of driving, and of the effect of radiation on efficiency, published in Kent's "Steam Boiler Economy," and also to Kent's formula for the efficiency of a boiler and furnace, which is as follows:—

$$\frac{Ea}{Ep} = \frac{K - tcf}{K(1 + R^s)} - \frac{966\, ac^2 f^2}{K(K - tcf)} \frac{W}{S}$$

in which Ea = actual evaporation per lb. of fuel; Ep = possible; K = heating value of fuel per lb. of combustible; $\frac{W}{S}$ = evaporation per square foot of heating surface per hour; t = excess of the temperature of the water in boiler

above atmospheric temperature; c = specific heat of escaping gases considered as a constant; f = weight of gases per lb. of fuel; R = radiation per square foot of heating surface per hour; W = water actually evaporated, in lbs. per hour reduced to equivalent evaporation from and at 212° F.; S = area of heating surface in square feet; a = a coefficient of resistance to transmission of heat and of other elements of inefficiency—most easily expressed by $a = \frac{A(T-t)}{cf}$, the numerical value of which lies between $a = 100$ and $a = 400$.

F. J. R.

1989. *Method of Determining Condition of Combustion.* **A. Bement.** (West. Soc. Engin., Journ. 6. pp. 204–217; Discussion, pp. 217–219, June, 1901.)—This paper contains the records of a number of determinations of the amounts of CO_2 and CO, with some of the oxygen also, found in furnace gases, these results being plotted as curves in fourteen diagrams. The determinations were made by means of Arndt's absorber and Arndt's gas-weighing econometer. The first instrument acts by chemical absorption, the gases being drawn from the flue by a small rubber hand-pump and thereafter exposed to the reagent in a simple manner, its maximum speed of operation being determinations at intervals of 30 seconds. In the second instrument a moving stream of gas is weighed by a delicate balance enclosed in an iron case with plate-glass front, the percentages being indicated by a pointer moving over a graduated scale. This instrument is automatic and continuous in its action and can be connected by pipes to several furnaces, the records being shown at a convenient point.

The theoretical maximum amount of CO_2 possible in the gases is assumed at 18 to 20 per cent. of their volume. If CO_2 existed alone in the gases its determination would be simple and its amount, compared with the theoretical maximum, would form a ready index of the condition of combustion. The presence of CO, however, complicates the matter, and the determination of its amount is needed to show whether the combustion has been influenced by excess of air or by incomplete combustion. Chemical analysis of the gases requires time for the determination first of the CO_2, then of the oxygen, and finally of the CO. It is maintained that the Arndt apparatus enables the volume of CO_2 to be compared with the prevailing conditions of the furnace during combustion. It is pointed out that CO_2 increases with reduced air supply or increased coal supply, showing that the air has been in excess of requirements. If it increases after increased air supply, that shows that incomplete combustion has prevailed. The formation of CO is usually due to insufficient air supply, but a case is quoted of increased volume of CO with a larger air supply. Incomplete combustion is due to irregular conditions with sufficient air as well as to deficient air supply. An accumulation of ash and clinker on the grate, or irregular firing, may account for its appearance under the former conditions. Thirteen per cent. CO_2 by volume is given as a common result with the less efficient kinds of furnaces, fluctuations being produced by the operations of stoking and slicing the grate. Examples of records from both instruments are given from furnaces with coal-dust fuel, hand-stoking good and bad, and mechanical stokers of various kinds with and without the necessary supplementary hand work.

In the discussion **Breckenridge** stated that if the CO_2 increases, the supply of oxygen must also increase. The econometer is in use at Illinois University and is found useful and very instructive to those who take an interest in it, whilst firemen can be made to understand that the pointer

should be kept at 12 to 14 per cent. in order that they may have the furnaces in the best condition. Replying to Professor Kerr, **A. Bement** stated that an irregular condition of the fire prevented the amount of CO_2 being maintained at the maximum, and instanced the diagram of results on two different occasions with the same chain-grate stoker, coal, and draught. In one case 17 per cent. CO_2 was maintained almost constantly, whilst in the other the percentage was first 5·5, then 7 in ten minutes later, 17 in twenty minutes, back to 9·5 in thirty minutes, at 14·5 in forty minutes, and at 11 in fifty-five minutes, these variations being caused by the method of using the fuel. F. J. R.

AUTOMOBILISM.[1]

1990. *Wilson and Pilcher Petrol Car.* (Automotor Journal, 5. pp. 449–451, June, 1901.)—A description of an experimental vehicle which has undergone extensive trials with success, and which possesses the special merit of being almost entirely free from noise and vibration. The engine is mounted near the front of the car frame, with its crank-shaft in the longitudinal direction. It has four horizontal cylinders, 3-inch bore by 3-inch stroke, mounted on opposite sides of an oil-tight crank chamber. The cranks are arranged in two pairs at 180°. This engine develops 5 b.h.p. at 1,000 r.p.m. The transmission gear between crank-shaft and live rear axle is entirely protected from dust and dirt by means of suitable casings. The change-speed gear is of the combined epicyclic and clutch kind, in which the whole mechanism revolves as one piece for the high speed, and for the low speed the power is transmitted through an epicyclic train of wheels. Two of these gears, each giving two speeds, are employed. They are arranged so that the power may be transmitted through one epicyclic gear only, or through the two coupled in series, and thence through a bevel drive and differential gear, to the live rear axle. Four speeds of 4·5, 7, 13 and 19 miles per hour at 1,000 revolutions of the engine are thus obtained. The reversing gear is formed by the use of two bevel wheels on the exterior of the differential gear box, either of which may be brought into engagement with the bevel pinion from the change-speed gear. The greater part of the weight of the driving mechanism comes direct on to the rear axle, the rear springs carrying only the weight of the carriage body and passengers. The steering of the car is on the Ackermann principle ; it is controlled by a hand-wheel acting through a pinion and quadrant. The road wheels have tangent steel spokes, and are 32 inches diameter front, and 40 inches diameter back. The wheel base is 6 ft. 3 in., and gauge 4 ft. 8½ in. C. R. D'E.

1991. *Trials of Motor Cars.* **W. A. T. Müller.** (Centralblatt Accumulatoren, 2. pp. 177–179, June 15, 1901.)—Hitherto, the few trials that there have been of motor cars have done nothing more than suggest improvements in manufacture, and have not increased our knowledge of the theoretical basis of calculation and construction. In June this year, the German Automobile Club organised trials in which for the first time theoretical considerations were to determine success. For each vehicle entered, the total loaded weight and the power of the motor had to be stated, and the winning vehicle was to be that whose speed most nearly approached the theoretical value calculated by a fixed formula from these data together with measured dimensions, &c. Though only petrol cars could compete, it is instructive to consider the general application of the results.

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

A formula for the "theoretical speed" in km. per hour is worked out, viz.:—

$$V = \frac{270\pi}{36000} \cdot \frac{D^2 H z}{Q} \cdot \frac{\eta_1 p_m n}{c},$$

Where D = cylinder diameter in cm., H = length of stroke in m., z = number of cylinders, n = revs. per min., p_m = mean cylinder pressure in kg. per sq. cm., η_1 = efficiency of the motor, Q = weight of vehicle in tons, c = traction coefficient in kg. per ton. In this formula the first two members are unalterable and definitely measurable for any vehicle: the third is the uncertain factor, and arbitrary values cannot fairly be given to it. It is therefore better to write—

$$c = \frac{1}{16} \cdot \frac{D^2 H z}{Q} \cdot \frac{x}{R} \eta_1 \eta_2 p_m,$$

Where R = radius of driven wheels, x = reciprocal of the gear ratio, η_2 = efficiency of the transmission gear.

If $\eta_1 \cdot \eta_2 = 1$, the only doubtful factor in the formula is p_m, for which an average value may be reasonably assumed. Then since the best vehicle is that which goes fastest with least expenditure of energy, the order of merit is determined by the smallness of $\frac{c}{V_e}$ where V_e is the observed speed.

E. H. C.-H.

1992. *Liverpool Trials of Motor Vehicles for Heavy Traffic.* (Automotor Journal, 5. pp. 419–441, June, 1901.)—A full description with numerous illustrations is given of the trials carried out by the Self-Propelled Traffic Association in June, 1901. A table is given of their leading dimensions, &c., and also one of hill-climbing tests.

The following table gives a summary of four days' run, showing relative consumptions, &c. :—

TOTAL DISTANCE EQUALS 168 MILES. AVERAGE PER DAY, 42 MILES.

Official Number of Car.	Total useful Ton-Miles.	Total Fuel Consumption.	Total Water Consumption.	Average Speed throughout per Hour.	Average Cost of Fuel per Day.	Average Cost of Fuel per useful Ton-Mile.
		galls. qts. pts.		miles	s. d.	pence
[1]A1	267	22 — 1	1 pt.	6·38	5 $6\frac{1}{4}$	0·99
[1]A2	272·5	18 1 —	$2\frac{3}{4}$ pts.	7·34	4 $6\frac{3}{4}$	0·80
		cwts. qrs. lbs.				
[2]B1	721	18 — 15	1,098 galls.	6·12	3 $4\frac{3}{4}$	0·23
[2]C1	1,014	28 — —	1,931 ,,	6·02	5 3	0·25
[2]D1	645	17 1 24	1,398 ,,	6·56	3 $3\frac{1}{2}$	0·24
[2]D2[3]	514[3]	18 3 6[3]	1,284[3] ,,	5·70	4 $8\frac{1}{2}$	0·33
[2]D3	624	21 2 18	1,447 ,,	4·64	4 $0\frac{1}{2}$	0·31
[2]D4	767	25 1 14	1,516 ,,	6·84	4 9	0·29

[1] Using petrol calculated at 1s. per gallon. [2] Using coke calculated at 15s. per ton.
[3] Three days only.

NOTE.—In these figures it should be noted that the actual useful loads carried exceeded those given in this table by some 10 per cent. to 30 per cent., it being impossible at present to ascertain the precise weights of passengers, observers, and extra fuel supplies.

C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

1993. *The Deboudé Electric Dynamometer.* **P. Deboudé.** (Ind. Élect. 10. pp. 254–256, June 10, 1901.)—This is a transmission dynamometer in which there is a spiral spring connected at its two ends to a central shaft and at its middle coil to a pulley capable of turning on ball bearings on the shaft. The relative displacement of the pulley and shaft is measured electrically by means of a contact roller, which is mounted on an arm fixed to the shaft and engages with a V-groove in a series of contacts on the pulley, equal resistances being connected between adjacent contacts. A constant current is sent through this resistance, *e.g.*, by means of a small magneto-machine having its armature on the dynamometer-shaft, and a dead-beat voltmeter connected to the contact-roller serves to indicate, by the voltage, the displacement of the pulley relatively to the shaft. C. K. F.

1994. *Energy Meter.* **F. Holden.** (Inst. Elect. Engin., Journ. 30. pp. 944–960; Discussion, pp. 960–968, June, 1901.)—A moving vertical spindle carries two shunt coils; these are flat coils, square in section, and are fixed in the same plane, one on each side of the spindle. Each is partially surrounded by a coil carrying the main current, and fixed in a perpendicular plane. The shunt coils can move through a certain angle, from one side of the main current coils to the other, and are held at one side by springs.

A clock closes the shunt circuit periodically, and the shunt coils rotate against the springs to the limits allowed by the surrounding main current coils; a pawl attached to the spindle engages a circular rack, and gives it the same angular velocity as the coils. The rack is mounted on a spindle axial with, but independent of, the spindle carrying the shunt coils, and gearing with the indicating train. A cast-iron disc fixed to the spindle rotates between the poles of a magnet, and by reason of its hysteresis acts as a brake; the spindle carries three weighted arms, to give the moving system a high inertia, and its rotation continues after the shunt coils are stopped till brought to rest by the hysteresis brake. The author shows that the angle through which the spindle turns is proportional to the product of the shunt and main currents. The clock mechanism consists of the seconds wheel and escapement parts of an ordinary clock; it is driven by a weighted lever carrying a pawl which gears with a ratchet wheel on the seconds wheel spindle When the lever has descended to a certain point, a contact is made which allows current to pass through an electromagnet and raises the lever this process is repeated about four times per minute. The average power required by the clock is 0·005 watt on a 100-volt circuit.

In the small sizes of meter the loss in the series coils is between five and six watts at full load, and in the shunt coils 0·17 watt. The results of a test show a maximum error of 1½ per cent. in a range from full load to 3 per cent of full load. The author discusses the errors likely to arise from changes in the brake magnet and from friction.

Discussion.—The author, in reply to several speakers, said that there has been no opportunity to take a time test of the meter; one meter, however, had been at the Board of Trade Laboratory for a year, and two others had been running for six months. The meter had been tested up to 500 per cent

overload, and was still accurate. He did not think any error could arise from the intermittent registration, in not keeping exact track of the load; at any registration, a positive or negative error was equally likely to occur, and in a three months' run these errors would certainly cancel out. Foucault currents are not induced in the brake disc to any appreciable extent. There is not much difference in the spark on breaking contact with continuous and with alternating currents. G. H. B.

1995. *Integrating Meters.* **H. Armagnat.** (Écl. Électr. 27. pp. 204–212, May 11, and 245–252, May 18, 1901.)—*Hookham Pendulum meter.*—A pendulum allows a clock-train, with indicating dials, to advance during a period of, say, five minutes; a clutch then reverses the direction of motion of the indicating train, so that in the next period of five minutes the train has returned to its original reading, assuming that the pendulum swings at the same rate. The pendulum, however, carries a pressure coil, which swings in a main current coil, so that, when current passes, the swing of the pendulum is quicker; at the same time that the clutch reverses the motion, a commutator reverses the direction of current in the shunt coil, so that in the next period of five minutes, while the train is moving backward, the swing of the pendulum is slower, and the dials at the end of the two periods indicate an amount proportional to the product of the currents in the two coils. An auxiliary clock is employed to reverse the direction of motion and of current. The meter is described fully with diagrams. *Bergmann meter.*—This is a meter of the Aron type with two clocks; instead, however, of registering continuously, a contact is made whenever one clock has advanced over the other an amount corresponding to, say, one-tenth of a unit; the contact closes the circuit of an electromagnet which registers this amount on a train. *Northey meter.*—This is for registering the charge and discharge of accumulators, taking into account the rate of discharge. A drum has a conical surface of form determined by the discharge curve of the battery; this is turned by clockwork and communicates its motion to a pointer through a friction wheel, the position of which on the drum is determined by an ammeter. For charge, the motion of the drum is reversed, and its rate altered so as to allow for the efficiency of the accumulators. The *Johnson and Murday meter* consists of a dynamometer-wattmeter and a clock, with intermittent integration. The *Tourtel meter* registers, by means of a clock, the deflection of an ammeter or wattmeter; a wheel, continuously rotating, during a portion of each turn brings the ammeter pointer back to zero, and during the motion of the latter is geared with the indicating train. In the *Schmidlin meter*, a clock turns a metal disc in the field of a shunt- and of a main-current coil, acting in opposition. At full load, the two fields annul one another, and the clock turns at its normal speed; the smaller the main current, the stronger the resultant field, and the more the clock is retarded. When no main current passes, a finger falls on the disc and prevents any motion. Two meters are described making use of bellows, the size of the escape orifice being determined by the current, and the number of times the bellows is discharged being recorded. G. H. B.

1996. *High-tension Switches and Fuses.* (Journal of Electricity, S.F. 10. pp. 117–139, June, 1901.)—These are a series of papers which were submitted for discussion at the Fifth Annual Convention of the Pacific Coast Electric Transmission Association, San Jose, June 18–19, 1901. **R. S. Masson** makes suggestions on high-tension switching. **F. V. T. Lee**

describes the Martin switch, **W. Currie** describes the latest Stanley types, and **H. C. Wirt** the latest General Electric types. **W. M. McFarland** gives an account of the latest Westinghouse types. In the 2,200-volt 1,000-ampere Westinghouse circuit-breaker the contact surfaces are made by laminated copper brushes against a flat copper block, and the contact pressure helps the releasing spring to throw out the movable arm when it is tripped. The current-carrying contacts are protected by copper shunts, so that when the breaker is opened current is gradually shunted from the current-carrying contacts to the carbons by steps of such low resistance that no arcing occurs.

The Westinghouse fused circuit-breakers are designed for potentials from 6,000 to 40,000 volts. This circuit-breaker is very simple, as it practically consists of two hardwood poles mounted upon a marble base. The poles are hinged so that their extremities are in line at the upper end, and on each is mounted a copper sleeve supporting a carbon contact block with a hole through its centre to hold the fuse wire. The longer pole is provided with spring jaws so that it may be quickly and easily attached to or detached from the terminals on the marble base. A flexible wire runs through the interior of the short pole, and the fuse wire, which is about 6 inches long, is connected across the upper ends of the two rods on poles. When the fuse blows, the short pole falls away from the stationary pole, and thus makes a long break. By means of a long string the fuse itself can be released, thus causing the short pole to drop, and so permitting the device to be used as a switch.

The articles are well illustrated. E. K. S.

1997. *Electric Pumps.* **F. A. Pattison.** (Eng. News, 46. pp. 4–6, July 4, 1901.)—This paper describes the installation of a new form of helical pump with direct drive by an electro-motor for the service of hydraulic elevators, and also for the supply of water under pressure for fire extinguishing, these being applications of very great importance for the very high buildings now becoming common in cities. To a great extent the operation is the same in both cases, being the supplying of a sudden demand for water by means which render this supply practically inexhaustible. As against steam boilers and engines on the premises, electro-motors, fed from the electric supply mains, to work the pumps showed, in the instance cited, a distinct economy.

The installation embraced a system of five hydraulic elevators in a ten-storey building, and there being a 500-volt power line in the vicinity, no steam was used in the building.

Two Quimby double-screw pumps, coupled direct to Eickmeyer electro-motors, were employed, and the governing was arranged so that when either of these units worked up to its full capacity the second one was switched in to share the load. The watt-hours of energy consumed per month were as follows: December 31 to January 31, 2,166,100; January 31 to February 28, 2,563,400; February 28 to March 31, 3,060,100; April 30 to May 31, 3,819,800. The cost of working can be deduced from these.

Whilst steam-pump manufacturers will guarantee an efficiency of 75 per cent. between steam and water, the efficiency between coal and water is very low, as the pumps require a large quantity of steam. In the case of this installation the efficiency between electric mains and water ranged from 47·74 per cent. to 60·05 per cent. Tables of tests are given of a fire-extinguishing plant consisting of a four-pole 75-h.p. motor, running at 675 r.p.m., and wound for 500 volts, direct coupled to a Quimby screw pump with pressure tank, the whole being controlled by a Ford regulator. The efficiency

varied from 59·9 to 67 per cent., with a head and lift of 285·5 to 151·5 feet respectively. Figures and curves are given. F. J. R.

1998. *A True Ground Detector.* **T. W. Varley.** (Elect. World and Engineer, 38. pp. 54–56, July 13, 1901.)—It is pointed out that the usual method of detecting a defect in the insulation of live circuits by the use of two lamps is likely to be fallacious, as it really indicates a *balance* of insulation resistance, and the two lamps burn equally, even though the actual resistance varies from nothing to a megohm. A means of definitely indicating a lowering of insulation below a certain standard by the ringing of a bell has been arranged. The author describes the application to an alternating-current station so as to test both the exciting and working sides. A relay is used and the connections so made that when a fault occurs, the potential difference at the terminals is lowered and the armature of the relay falls and establishes the bell circuit. A convenient method of testing the actual insulation by means of a Weston voltmeter is described. It is also shown how signalling may be performed between stations. The system has proved of great service. W. W. H. G.

1999. *Lightning Arresters.* **C. C. Chesney.** (Elect. World and Engineer, 37. pp. 942–944, June 1, 1901.)—After enumerating the defects usually met with in alternating-current lightning arresters—too long or too short a spark-gap, bad insulation, inability to break quickly the arc formed by a discharge, exposure of the line terminals, and inability to deal with heavy discharges—the author describes a form of arrester designed to overcome them. It consists of two pairs of concentric cylinders with diverging conical ends held in position by porcelain caps at top and bottom. These caps have concentric circular grooves to receive the ends of the cylinders, and are pierced with ventilating holes between the grooves. The latter are so spaced as to make all spark-gaps $\frac{1}{16}$ inch wide. The space between the inner and outer cylinders is spool-shaped, and the intermediate pair of cylinders have straight generators, except for a short distance at top and bottom on the sides facing one another where they diverge. The inner cylinder is connected to the line and the outer to the earth. When the arrester is in operation, if the dynamo current follows the lightning, a current of air is at once established between the cylinders, and the arc is thereby blown upwards into the wide spaces between the ends of the cylinders, where it is quickly ruptured. At the frequencies usually employed, 5,000 volts or over are required to jump the gaps of this arrester; but at the frequency of a lighting discharge the sparking potential is less than 2,500 volts, so that although the spark-gaps are at least double the widths usually employed, yet the sparking potential at lightning frequencies is less, and the large discharging area of the cylinders enables the arrester to take heavy discharges with ease. Between the arrester and the machine to be protected is placed a coil formed of two coils side by side connected in series, but so that the current circulates in opposite directions, thus making the self-induction of the coil for ordinary frequencies nearly zero. The utility of this arrangement depends on the fact that the impedance of such coils to lightning discharges is practically as great as that of ordinary coils, and hence the discharge finds an easier path to earth through the arrester.

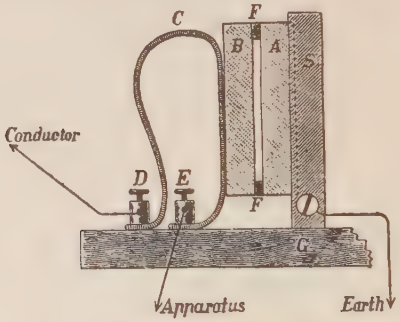
To protect the line from small and low frequency lightning discharges, and from static charges, a line discharger is recommended to be used with the arrester described. This discharger is simply a tube of oxidised metallic

particles, with one end connected to the line, and the other, through a minute spark-gap, to the ground, the length of the tube depending on the voltage of the line.

For high-pressure lines, arresters are joined in series. The paper contains diagrams of arresters and of arrester and line discharger connections.

J. H.

2000. *Coherence Phenomena in Carbon Lightning Arresters.* **M. H. Gansauge.** (Journ. Télégraph. 25. pp. 97–99, May, 1901.)—The construction of these lightning arresters is shown in the figure. G is a wooden base-board supporting a metal plate S connected to earth. A number of plates—equal to the number of lines to be protected—of compressed carbon are fixed in a series of parallel grooves in S; and against each of these plates, A, is pressed a second carbon plate, B, by a steel stirrup spring C. The plates A, B, are kept apart by two insulating blocks, F, about 0.08 inch thick, and have their inner edges serrated to facilitate discharge between the plates. The line connections are shown at D and E. In ordinary working no current passes from B to A; but if the line is struck, or inductively acted on by lightning, a discharge takes place along this path to earth rather than along the highly inductive path through the telephone instruments, so that no damage is done to the latter. The carbon plates of the lightning arrester should be very care-



fully dusted when setting up the instrument, otherwise carbon dust is liable to settle on the insulating blocks, F, and to destroy the insulation. It is not sufficient to test the instrument for insulation in the ordinary way. Experiments have clearly shown that a coating of carbon dust may not destroy the insulation of the blocks until a spark discharge passes, when the dust coheres and forms a short-circuit, as in the well-known case of the coherers used in wireless telegraphy. To make a proper insulation test, therefore, a spark must first be made to pass between the plates A, B; otherwise the instrument may appear all right, but after a time suddenly go wrong without any apparent cause, owing to a short-circuit produced by a discharge between the plates due to atmospheric causes. Microphones consisting of carbon particles mixed with carbon dust, are also liable to coherence phenomena, and the noises sometimes heard in telephones, when the circuits are not in use, may be explained in this way.

J. H

2001. *Electrical Installations in Battleships.* **Grauert.** (Elektrotechn. Zeitschr. 21. pp. 970–977, Nov. 22, and 992–997, Nov. 29, 1900. Paper read before the 8th Jahresversammlung des Verbandes Deutscher Elektrotechn. i

Kiel.)—The author gives a descriptive list of the various ship-lights, signalling-lights, and projectors with which the German ships are fitted. He next compares the different systems of machine and steering telegraphs, rudder indicators, and torpedo signals, giving preference to those constructed by Siemens and Halske. As reserves to these, either speaking-tubes or telephones are installed; the latter, however, are open to some objections. As regards the system of supply, continuous current only is employed, in view of the large amount of power required for the projectors; alternate current is out of the question, on account of the large motor service, and three-phase current has the disadvantage of a more complex network, while the speed of motors can be varied only within small limits. In the latest ships, a voltage of 74 has been adopted as the best adapted to projectors; motors for this pressure have, however, to be specially constructed, and on this account it is probable that the more usual pressure of 110 volts will be finally adopted. Compound machines are now no longer used, on account of the risk in parallel coupling by unskilled men. The switchboards are usually constructed with one negative and two positive bus-bars, so that the motor circuits with variable load may be kept separate from the lighting and the ventilating-motor circuits. A reserve machine and switchboard are usually sufficient only for the lighting, signalling, and ventilation. In the ship *Kaiser Wilhelm II.*, a single lever is arranged so as to change over all these circuits from the principal to the reserve plant. This, though convenient, has the disadvantage that a single shot may damage all the circuits.

The loss of a Spanish ship due to sudden extinction of her lights when entering a harbour, showed the necessity of an accumulator reserve. The battery can be either permanently connected across the mains, or act as an independent source of supply. The former method is not advisable, as either the supply pressure of the battery must be less than the normal voltage, or else the battery must be charged in two series, in which case the reserve is not available during charge. The better system is to instal a battery to supply the signal lamps, which can be charged during the day, while the telegraphs and telephones are supplied by two batteries giving 36 volts each, one being charged while the other is discharged. In the "Fürst Bismark," however, the telephones and telegraphs are supplied from two independent continuous-current transformers, taking current from the main battery of accumulators. Detailed diagrams of the connections in several of the German battleships are given.

The wiring is carried out with lead-covered cable, which is armoured in places where subject to mechanical injury; in the cabins heavily insulated rubber wires are run without casing. The go and return wires are separate, except in the neighbourhood of the compass, where concentric cables are advisable. Soldered joints are avoided, as they are liable to become loose from the vibration of the ship's body, and all branch circuits are connected through distributing bases; these are illustrated and described in detail.

The author finally gives tables showing the power required for the various purposes in five German ships, and also particulars of the dynamos in ten ships. G. H. B.

2002. *Coal Conveyors in Central Stations.* **R. A. Chattock.** (Elect. Rev. 49. pp. 77–78, July 12, 1901. Paper read before the Municipal Electrical Association at Glasgow.)—A station must store at least 100 tons of coal for every 1,000 i.h.p installed. This amount can be conveniently contained in bunkers above the boilers. But it is desirable to store five times this amount,

if possible ; and for this purpose an auxiliary coal store is necessary, from which the overhead bunkers are supplied by conveyors. The flooring of any coal store should slope at an angle of 45° to points in the centre, from which points a supply of coal is drawn off. The maximum depth stored should be 10 feet ; if this is exceeded the coal is liable to become overheated, and to catch fire. The author then describes in outline the various forms of conveying apparatus, including the worm, chain, push-plate, band, trough, bucket, and trolley types, and points out the advantages and disadvantages of each. With regard to elevators, the bucket and grab types are mentioned. Seeing that apparatus of this kind is peculiarly liable to break down, duplicate means should be provided for getting coal into the station. W. H. S.

2003. *Transmission of Compass Readings.* **C. L. Weber.** (Elektrotechn. Zeitschr. 22. pp. 403–405 ; Discussion, p. 405, May 9, 1901. Paper read before the Elektrotechn. Verein, March 26, 1901.)—The suggested plan of removing the compass to the masthead or other part of the ship remote from magnetic disturbances due to local causes, requires a means for transmitting the compass readings to the deck or bridge. The possibility of being able to replace the compass needle by an earth inductor coil is considered, and various methods for obtaining the best conditions of working are mentioned. Equations for the corresponding currents are given, but no practical system for transmitting and interpreting them has yet been put to the test of experiment. In the discussion, **M. Fuss** described a method in which the receiver is a primitive form of a three-phase motor, consisting of a pivoted astatic needle about which are placed three fixed coils at 120° from each other. The sender is a compass needle carrying insulated contact projections dipping into liquid contained in three annular rings cut in the insulating base-board. The inner two rings contain mercury, and are connected respectively to the terminals of a sending battery. The outer ring contains zinc chloride solution, and contact is made with this solution at three points 120° from each other, by three wires connected respectively to the three coils of the receiver. By means of the contact projections, the compass needle connects the inner mercury ring to the outer electrolyte ring ; and by a second pair of contacts, insulated from the first, it connects the other mercury ring also with the outer electrolyte ring. The contact projections are all in the same straight line beneath the moving needle ; there is consequently a change of resistance of the circuits corresponding to each angular movement, and a corresponding change of magnetic field at the receiver, causing, it is stated, a corresponding rotation of the astatic needle. R. A.

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2004. *Controller for Three-phase Induction Motors.* **W. Ephraim.** (Elektrotechn. Zeitschr. 22. pp. 465–466, June 6, 1901.)—The advantages which, in addition to the magnetic blow-out arrangement, are possessed by the controller used for continuous-current motors, are—(1) for each position, a new contact-arm comes into play ; (2) the points at which the breaks occur are separated from each other by fireproof partitions. In order to secure the last two advantages for the starting-switches used in connection with three-phase induction motors, the Helios Company has adopted a controller type of switch patented by the author. The paper contains a detailed description, with illustrations, of this type of switch. A. H.

2005. *Covent Garden Theatre.* (Electrician, 47. pp. 85–88, May 10, 1901.)—A general description of the electric stage-mechanism.

GENERATORS, MOTORS, AND TRANSFORMERS.

2006. *Standard Tests for Electrical Machinery.* (Elektrotechn. Zeitschr. 22. pp. 477–480, June 13, 1901.)—This article contains the draft of the report of the Committee appointed by the Verband Deutscher Elektrotechniker for the purpose of standardising the tests to be applied to German electrical machinery. This draft has been drawn up after consultation with manufacturers and experts, and will be laid before the meeting of the Verein at Dresden for consideration. The following points from the proposed regulations may be noted: All temperatures to be taken by means of a thermometer, except in the case of magnet coils; in the latter case, the rise of temperature is to be ascertained by the resistance method, the temperature coefficient for copper being taken as 0·004 per 1° C. In ordinary cases, where the air temperature does not exceed 35° C., the rise of temperature in insulated windings, commutators, and slip-rings, is not to exceed the following amounts, viz., for cotton insulation, 50° C.; for paper insulation, 60° C.; for mica and asbestos, 80° C. For stationary windings these figures may be exceeded by 10° C. For tramway motors, after one hour's run at full load, the above figures are to be taken as 70°, 80°, and 100° respectively. All machines to have a plate stating voltage, current, periodicity, power factor, &c. The plate is also to state whether they are intended for intermittent or continuous use; for these two classes of machinery different regulations are prescribed. All generators, motors, and rotary converters are to stand an overload of 25 per cent. for half an hour without exceeding the above-stated temperatures; similarly motors, rotary converters, and transformers are to stand an overload of 40 per cent. for three minutes. Generators must be able to keep the voltage constant up to 15 per cent. overload, when running at constant speed, the power factor in the case of alternators being taken as not less than that stated on the plate. The insulation of all machines must be able to withstand the following tests for half an hour, viz., twice the working pressure for machines under 5,000 volts; an increase of 5,000 volts on the working pressure for machines between 5,000 and 10,000 volts; above this limit the testing pressure to be one and a half times the working pressure. In case the insulation of direct-current machines is tested with alternate current, the above pressures to be multiplied by 0·7. These tests to be carried out when the machine is hot. The efficiency of the machine is to be determined by one or other of the eight methods laid down in the regulations, it being assumed for the purposes of the test that in the case of an alternate-current machine the power factor is unity. Conditions are also laid down for the determination of the drop in voltage between no load and full load in the various types of machinery. W. H. S.

2007. *High-frequency Alternator.* **H. F. Chadwick.** (West. Electn. 28. pp. 440–441, June 29, 1901.)—A discussion of the "skin effect" produced in conductors subjected to a potential difference alternating at high frequency, followed by a short description of the high-frequency alternator designed by W. L. Hooper and used for experimental purposes at Tufts College. The alternator is driven by a direct-current motor mounted on the same base and coupled direct; the speed is 2,500, which,

with 48 armature coils (the number on the machine), gives a periodicity of 1,000 per second. The alternator is of the Mordey type; all the armature coils are provided with terminals, so that they can be coupled in series or in various combinations of series-parallel. The output of the machine, with the coils in series, is from 7 to 10 amperes at 100 volts. The Mordey field is 16 inches in diameter and consists of two cast-iron crown wheels with teeth milled out of the solid. The axial magnetising coil is of the usual Mordey type, and the collecting rings are mounted on one face of the field, the brushes being set horizontally. The armatures of motor and generator are each mounted on ball bearings; there are three pedestals, the intermediate one being common to both, and the two shafts are connected by a clutch in the body of the pedestal. Friction is reduced to a minimum by the ball bearings; the machine takes ten minutes to come to rest from full speed with all circuits open. The e.m.f. curve is very nearly a sine wave. The paper is illustrated by a photo block and a detail drawing (plan and elevation). B. P. S.

2008. *Polyphase Sub-station Plant.* **H. S. Meyer.** (Elect. Rev. 49. pp. 5–7, July 5, 1901.)—The author continues the discussion of the questions raised by Hobart and Eborall [see Abstracts Nos. 1802, 1822, and 1823 (1901)]. The discussion hinges mainly on the following points: (1) whether or not damping coils are essential to rotary converters, and the amount of the losses occasioned by their use; (2) the efficiency of the rotary converter, including auxiliary apparatus in the shape of transformers, damping coils, &c., as compared with the synchronous motor-generator; (3) the pressure tests to be applied to armature insulation; and (4) the amount and calculation of the necessary fly-wheel effect. With regard to (4), the following is the method employed by the General Electric Company, of America, for determining the variation of the angular velocity of the flywheel. A bicycle wheel is directly connected to a ½-kw. bipolar generator, and mounted so that the tyre presses against the rim of the engine flywheel. The field is excited by a storage battery, and the armature is connected in opposition to another battery. A voltmeter is connected between the two. The voltages of this battery and of the dynamo are adjusted so as to be nearly equal, and any variation in the angular velocity will therefore be reproduced on the voltmeter. The method, being differential in its action, is very sensitive.

The article contains some calculations referring to matters connected with the flywheel effect, and the allowable variation in angular velocity. **Eborall** published a reply in the Elect. Rev. July 12, 1901, pp. 51–52; and **Meyer** published a counter-reply in the Elect. Rev. July 19, 1901, pp. 95–96.

W. H. S.

2009. *Theory of Synchronous Motors and of Alternators in Parallel.* **A. Russell.** (Elect. Rev. 48. pp. 919–921, May 31, pp. 995–996, June 7, and 49. pp. 88–89, July 19, 1901.)—This is a theoretical discussion demonstrating the following results:—

(1) There is only one position of lag or lead of a synchronous motor on a given load where the equilibrium is stable.

(2) It is necessary to adjust the excitation of both the motor and the generator when we wish to get the maximum efficiency.

(3) It is misleading to refer to a synchronous motor as having a certain power factor at a particular load. The power factor of a motor circuit is a variable that depends not only on the shape of the wave of the generator, but also on what is happening outside the motor circuit.

(4) The greater the excitation of two alternators working in parallel, the nearer the angle of lag between the synchronising e.m.f. and the synchronising current is to 45°, and the less the resistance of the circuit of the armatures the better they will work in parallel.

(5) Alternators will in some cases cease to work in parallel on heavy inductive loads. This could be remedied by connecting condensers or over-excited synchronous motors either directly or through the medium of a transformer to the bus-bars. W. G. R.

2010. *Theory of Synchronous Motors.* **A. Blondel.** (Écl. Électr. 27. pp. 429–442, June 22, 1901.)—The elementary theory of a generator and a synchronous motor is first discussed, the permeability of the inductor circuit being considered constant. If E_1 and E_2 be the generator and motor e.m.f.'s, $\pi-\theta$ their phase difference, I the current, Z the impedance of the whole circuit, γ the angle of lag of I behind the resultant of E_1 and E_2, and P_1, P_2 the power given out and absorbed by the generator and motor respectively, then—

$$(ZI)^2 = E_1^2 + E_2^2 - 2E_1E_2\cos\theta$$

$$P_1 = \frac{E_1}{Z}\left\{E_1\cos\gamma - E_2\cos(\theta+\gamma)\right\},$$

$$P_2 = \frac{E_2}{Z}\left\{E_1\cos(\gamma-\theta) - E_2\cos\gamma\right\}.$$

The ordinary diagram of the working of the two machines in series is simplified by choosing different polar axes and different scales for the e.m.f.'s and currents. The line on the diagram that represents the resultant e.m.f. (ZI) also represents the current (I). Lines OA_2 and OA_1 representing E_2 and E_1 are drawn inclined to one another at an angle θ so that A_1A_2 represents ZI. When we are considering the case of E_2 fixed, a line YA_2Y' is drawn making an angle $\pi-\gamma$ with OA_2. Then we can regard A_1A_2 as a vector representing the current, the angle A_1A_2Y representing the phase difference (ϕ) between I and E_2. We thus get a bipolar diagram, the vector E_1 rotating about O whilst the vector I_1 rotates about A_2. This simplifies the theory. The author shows, for example, how the V curves can be found from a purely graphical construction. A numerical example of two Mordey alternators (2,000 v., 18·5 a.) operating through a line 10 kilometres long is completely worked out. The constants of the armatures, determined from the characteristic curves given by Mordey, are 3 ohms resistance and 43 ohms reactance.

The latter half of the paper treats of the variation of the reactance of a synchronous motor under various conditions of working. The variable inductance of the armature can be found from two reactions which can easily be calculated in practice. The first reaction directly opposes the magnetising turns of the inductor poles and may be written $k\frac{nI\sin\phi}{\sqrt{2}}$ and the second reaction $k'\frac{nI\cos\phi}{\sqrt{2}}$ acts transversely on the poles. These magnetising forces act on different magnetic circuits. In the formulæ k and k' are constants, n is the number of armature windings in the field of an inductor pole, and ϕ is the phase difference between I and E_2. The saturation of the inductor poles is taken into account, as knowing the ampere turns we can get the resultant flux in them from the excitation curve of the machine found experimentally on open circuit. The transverse flux can in general be represented by $LI\cos\phi$ where L is a constant. A graphical method is given of finding the

wattless current ($I \sin \phi$) as a function of the excitation, and hence the true V curves can be found. The author states that the principle of two reactions also directly applies to the study of rotary converters. A. R.

2011. *Polyphase Induction Motors.* **R. D. Mershon.** (Elect. World and Engineer, 37. pp. 966–967, June 8, 1901.)—In this paper the author compares the polyphase-induction motor with the direct-current motor with regard to starting torque, speed control, disturbance at starting to the voltage of supply, and power factor. The induction motor may have a higher starting torque than a direct-current motor under any conditions. The direct-current shunt motor and the induction motor with slip-rings and rheostat in the secondary circuit are identical as to speed control, and the same applies to a motor without slip-rings, controlled by varying the impressed voltage. The disturbance to the circuit is slightly greater with the induction motor, owing to the power factor being less than unity. With an induction motor without slip-rings, started under load or run below speed, the disturbance will be greater since the power factor becomes less. Power factor does not affect the efficiency of the polyphase induction motor; it only affects the supply circuit, and is modified by the power factor of other apparatus on the same circuit. In conclusion the author discusses the relative efficiency and cost of direct current and polyphase induction systems for power service. The synchronous motor is ignored as not being sufficiently simple or reliable under varying conditions. B. P. S.

2012. *Efficiency and Running Cost of Shunt Motors.* **B. Frankenfeld.** (Elect. World and Engineer, 38. pp. 17–19, July 6, 1901. Paper read before the North-western Electrical Association.)—The method of determining the efficiency by measuring the losses is recommended; an example is fully worked out for a 5-h.p. motor. The effect of varying the incidence of the losses in different motors is then shown by means of curves, and it is pointed out that shunt motors which have their maximum efficiency at a small percentage of their full load have very poor speed regulation; this may be remedied by differential compound winding. The effect of efficiency upon running cost under steady and variable loads is dealt with, and it is recommended that for general purposes the maximum efficiency should occur at three-quarters of the full load. A summary of conclusions is given, in which it is stated that the maximum efficiency occurs when the ohmic loss in the armature equals the sum of the fixed losses; an early maximum impairs the regulation, but a late maximum gives greater overload capacity; the maximum efficiency should not in general occur at the average load. A. H. A.

2013. *Heating of Magnet Coils.* **S. S. Neu, A. J. Levine,** and **O. A. Havill.** (Elect. World and Engineer, 38. pp. 56–58, July 13, 1901.)—An investigation with the objects of determining the distribution of heat in the coils of field magnets under various conditions, the relation between rise of temperature and watts per square inch of radiating surface, the time required for coils to heat and cool, and the relation between the rise of temperature as measured by thermometer and as measured by increase of resistance. The experiments have been carried out in a complete and interesting manner. The coils used were from two shunt 115 volt, 1 and 5 h.p. motors. The coils were specially wound in 16 sections of equal cross sections so as to admit of finding the temperature by the resistance method in any of the 16 compartments. The coils were tested (*a*) supported entirely

in air, (*b*) resting on a table, (*c*) in place on the machines, and (*d*) with the machines running at full load. The coils were heated for six hours at their rated voltage under each of these conditions. Isothermal curves were plotted. The ratio between the rise of temperature of the hottest point of the winding and the mean rise of temperature was in the four cases—(*a*) 1·135, (*b*) 1·17, (*c*) 1·21, (*d*) 1·12. A coil whose surface is all exposed to the air radiates 0·00292 watt from each square inch of surface for each degree difference in temperature between the coil and the air, and finally the following simple formulæ are deduced :—

For electromagnets $W = TS/100$;
For field magnets $W = TS/110$,

where T = allowable rise of temperature in degrees C.,
W = watts which will produce this rise,
S = outside cylindrical surface of coils in square inches.

Formulæ are also obtained for the rate of heating and of cooling, and it is shown that the time required for a coil to attain a constant temperature is proportional to its cylindrical surface divided by its volume. One of the useful results is a comparison between the thermometer and resistance methods. According to G. S. Dunn, it is stated that the temperature as measured by a thermometer can be varied by 5° by changing the method of measurement. To obtain uniform results he limits the amount of cotton-waste usually applied over the thermometer's bulb to prevent radiation. He advises the use of a fibre tube 1½ inches diameter and 4 inches long with a slot in one side. This is pressed against the surface to be measured, the thermometer inserted in the slot, the box then packed with cotton, and the whole tied to the surface with rubber tape. Dunn also remarks that the difference between resistance and thermometer measurements is greater than is implied by the rules of the American Institute of Electrical Engineers. The authors find (using Dunn's device) that there is no simple relation between the thermometer rise and the rise by resistance. In practical cases the ratio is not above 0·6. W. W. H. G.

2014. *Testing Large Transformers.* **J. S. Peck.** (Elect. World and Engineer, 37. pp. 1083–1086, June 22, 1901.)—The transformers in question (seven in number, each of 2,250 kw. capacity), were installed near Buffalo, N.Y., by the Cataract Power and Conduit Company, for the purpose of reducing the pressure of the Niagara Falls three-phase transmission circuit from 22,000 to 11,000 volts. Each transformer is enclosed in a case of boiler plate, with oil-insulation, the oil being cooled by a circulation of cold water through spirals of brass tubing. A thermometer shows the temperature of the oil, and automatically sounds an alarm gong when this reaches a certain value.

The following figures are given as the result of actual tests :—Efficiencies : Full load, 98·65 per cent. ; three-quarter load, 98·58 per cent. ; half load, 98·33 per cent. ; quarter load, 97·2 per cent. ; pressure drop on a non-inductive load, 0·76 per cent. ; on a load with power factor of 80 per cent., 1·8 per cent. Actual temperature rise as measured by increase in resistance, 28·7 per cent. All transformers stood the following high-pressure tests : 45,000 volts for one minute between high-tension and low-tension winding, and between high-tension winding and core ; 22,500 volts for one minute between low tension winding and core ; 49,400 volts on the high tension winding (induced by 2¼ times the normal voltage applied to the low-tension winding) for thirty

minutes. Resistance was measured by passing a current of about 6 amperes through the coils from storage cells and taking the fall of potential by means of a voltmeter, a high resistance being inserted in series with the windings. It was found necessary to short-circuit one of the other windings when making the test, in order to obviate the danger to the instruments which would result from the high e.m.f. which would be induced in the circuit due to even a slight change in the current. The effect of the short-circuited windings is to increase the time necessary for the magnetic field to reach its full strength after the current is switched on; with the low-tension coils all in series the time required is about thirty minutes; with the high-tension coils all in series, about three minutes. A true reading of the pressure drop is only obtained after the field has become stationary, as the changing field induces an e.m.f. in the coil which adds itself to the voltmeter reading; curves are given showing the apparent decrease of resistance of the coils with time. Total iron losses were measured in the usual way by a wattmeter. To separate the eddy current from the hysteresis loss the latter was measured by a method due to C. F. Scott. A direct current is sent through the low-tension winding and gradually increased or decreased. The changing field induces an e.m.f. in the transformer winding which is measured by a voltmeter across the high-tension winding. The voltmeter needle was found to remain steady at a reading of 0·1 volt when the field changed at the rate of about 6 c.g.s. lines per sq. cm. per second; hence, the resistance being gradually cut out so as to keep the voltmeter steady at this value, the time from the start is a measure of the induction in the iron. When the maximum desired induction is reached the voltmeter is reversed and the current gradually decreased to zero, and so on till the cycle is complete. Readings being taken of time and current (the voltmeter needle being held steady the whole time) a curve is obtained from which the hysteresis loss can be readily estimated. The eddy current loss is then obtained by deducting the hysteresis from the total iron loss. Efficiency and hysteresis curves accompany the paper, and also photo blocks showing the transformers in different stages of assembling. B. P. S.

2015. *Reactance Drop and Reactance Factor of Transformers.* **A. E. Kennelly.** (Elect. World and Engineer, 38. pp. 92–94, July 20, 1901.)—For any definite load a transformer is equivalent, so far as the external primary circuit is concerned, to a certain choking coil inserted in the primary circuit. The percentage of the drop of pressure in the equivalent choking coil is equal to the percentage of the drop of pressure actually occurring in the secondary of the transformer. If e_r and e_x be the resistance and reactance drops in the equivalent choking coil, then—

$$e_x = \left\{ E_1^2 - (E_2 \cos\theta + e_r)^2 \right\}^{\frac{1}{2}} - E_2 \sin\theta,$$

where $\cos\theta$ is the power factor of the load on the secondary circuit, E_1 the primary volts, and E_2 the volts at the secondary terminals multiplied by $\frac{n_1}{n_2}$, where n_1 and n_2 are the primary and secondary turns respectively. Now e_r can be calculated from the resistance of the primary and secondary windings, and hence e_x can be found from the formula. The author defines the ratio of e_x and e_r as the reactance factor of the transformer, and says that it varies in practice between 2 and 20 depending on the size, pressure, and design of the transformer. The lower the reactance factor the better the

regulation of the transformer. With a good transformer of low reactance factor on a non-inductive load, e_r is approximately equal to $E_1 - E_2$, and hence can be found without calculation. The following approximate formula for the reactance factor (f) is given :—

$$f = \frac{N - n\cos\theta}{n\sin\theta},$$

where N is the percentage secondary drop of a transformer on inductive load of power factor $\cos\theta$, and n is the percentage secondary drop of the same transformer on non-inductive load. Suppose, for example, that a transformer has a secondary drop of 0·75 per cent. at full non-inductive load, and a secondary drop of 1·8 per cent. at full load current on a power factor of 0·8, then $\cos\theta = 0{\cdot}8$, $\sin\theta = 0{\cdot}6$, $n = 0{\cdot}75$, and $N = 1{\cdot}8$; hence $f = 2{\cdot}67$. The reactance drop in this transformer is thus $2\frac{2}{3}$ times the resistance drop. A table is given, calculated on the sinoidal assumption, of the reactance factors of transformers on various inductive loads when the ratio of the inductive load drop to the resistance drop is known. A. R.

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2016. *Alternator Diagrams.* **L. Barbillion.** (Écl. Électr. 27. pp. 408–413, June 15, 1901.)—Simple diagrams illustrating the working of an alternator connected on to a network of mains are given for distribution at constant e.m.f., at constant current and at constant p.d. Proofs of these diagrams assuming the ordinary sine-curve theory are given, and the conclusions to be deduced from them illustrate clearly some of the main phenomena observed in practice. A. R.

2017. *Aluminium for Electrolytic Rectifiers.* **C. Pollak.** (Comptes Rendus, 132. pp. 1405–1408, June 10, 1901.)—Note on the forming of aluminium plates for this purpose. A. D.

2018. *Standard Tests for Electrical Machinery.* **G. Dettmar.** (Elektrotechn. Zeitschr. 22. pp. 499–506, June 20, 1901.)—The author here publishes some notes on the Report of the Committee appointed by the Verband Deutscher Elektrotechniker for the consideration of this subject [see Abstract No. 2006 (1901)]. He states the reasons which led the Committee to adopt the various regulations, and adds suggestions as to the best means of carrying out the tests, and the precautions to be adopted to secure satisfactory results. W. H. S.

2019. *Starting Rotary Converters.* **A. B. Weeks.** (Amer. Electn. 13. pp. 358–360, July, 1901.)—Some notes on the starting of rotary converters from the practical point of view. The information, which is given in some detail, cannot well be condensed. W. H. S.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2020. *Resonance in Continuous-current Circuits.* **H. Armagnat.** (Écl. Électr. 27. pp. 465–468, June 29, 1901.)—The voltage curve of a continuous current dynamo is not an exact straight line. The deviation from the mean in a 60-ampere 120-volt dynamo with a Gramme ring experimented on was 1 or 2 volts. On putting a four-pole motor with a slotted armature in circuit, the maximum amplitude of the voltage variation became 14 volts. The number of segments on the commutator of the motor was 24, and its speed 1,200 r.p.m. Hence the frequency of the superposed alternating voltage was 480. The current taken by the motor was only about 4 amperes. Putting an induction coil (L) and a condenser (K) in series across the circuit and adjusting to resonance, then if E be the effective alternating voltage between the mains and V the voltage across the choking coil,

$$V = \frac{2\pi f L}{R} E.$$

In the experiment L = 1 henry, R = 105 ohms, K = 0·11 microfarad, $f = 482$, V = 140 volts. Therefore E is 4·85 volts, and if the wave be sinoidal the maximum value of E is 7 volts on either side of the mean voltage. On varying K to 0·10 or 0·12 microfarad, V dropped to under 20 volts. It is suggested that this arrangement can be used for indicating harmonics or indicating speeds. Apparently inexplicable breakdowns of cables in continuous-current circuits may be due to resonance. When a Wehnelt or Caldwell interrupter is put on commercial circuits a difference of 4 or 5 volts is sometimes noted between the readings of thermal and magnetic voltmeters which ordinarily read the same. In the circuit experimented on above, a Wehnelt interrupter made the maximum voltage 240 volts, *i.e.*, double the mean voltage. Mechanical resonance also can be caused by the undulations in commercial continuous currents. A. R.

2021. *Dielectric Losses in Condensers and Cables.* **C. V. Drysdale.** (Electrician, 46. pp. 890-892, April 5, 1901.)—The author proposes the use of condensers in transformer substations to provide a current in quadrature, to be supplied by an auxiliary line for starting single-phase motors. A 20-microfarad condenser on a 2,000-volt 50 ∿ circuit takes 13·5 amperes, and this, if transformed to 100 volts, would give 250 amperes in quadrature with the lighting mains, and would be sufficient for starting a large number of motors. The dielectric loss in the condenser would be a serious objection to this system, and the author gives the result of measurements of the power factor of various cables and condensers. He also has compiled a table summarising the power factors measured by Ayrton, Mather, Hóor, and Addenbrooke.

G. H. B.

2022. *Power lost in the Dielectric of Cables.* **W. M. Mordey.** (Inst. Elect. Engin., Journ. 30. pp. 364–387 ; Discussion, pp. 396–473, April, 1901.)—With sine-curve alternators the capacity current in a cable = *Volts* × *periods per*

second × *microfarads* × $2\pi \times 10^{-6}$. On a particular rubber insulated 37/15 cable for 7,000 volts this measure was found to be independent of the voltage, and the capacity therefore did not vary with the pressure. The C^2R loss due to the capacity current is small, as is also the leakage loss, but the loss of energy due to rapidly reversing the strain on the dielectric in the above cable was large, namely, 0·124 of the "volt-amps", or "apparent watts." The author says that this dielectric loss may be diminished by increasing the thickness of insulation, and that it resembles magnetic hysteresis, from which it differs by showing no saturation effect. Possibly at very high pressures the proportionality may cease and the curve begin to bend down towards the axis of volts. This loss continues always, and often is more important than the C^2R loss. Thus on 40 miles of cable having 0·5 mfd. per mile and working at 20,000 volts (50 ∿), 300,000 units would be wasted per annum. A choking coil should be placed in parallel with the capacity and if it takes a self-induction current equal to the capacity current, the two will neutralise. The dielectric loss in small cables is disproportionately large because the capacities do not much lessen with decrease of size. The dielectric loss is said to be proportional to the square of the pressure. The author has noticed that when extra high-tension mains are switched on, the engine has been checked much more than would be consistent with the production of merely wattless current. Particulars are given of a choking coil with closed magnetic circuit used to reduce the wattless current on 5½ miles of 37/15 7,000-volt mains. The reduction due to the ordinary transformers is very small, and the author prefers to keep to transformers with a low power factor and to provide separately for any compensation that may be necessary. An over-excited synchronous motor acts as a capacity and takes a leading current; when under excited it takes a lagging current.

Discussion.—**W. E. Ayrton** pointed out that ammeter readings had already been used to measure capacities and that the method was not novel. He claimed to improve on Mr. Mordey's choking coil by giving to the inductive shunt a value of—

$$\frac{1 + \sqrt{1 + 4F^2p^2o^2}}{2Fp^2} \text{ henries}$$

where F is the capacity of the cable in farads, p is 2π times the frequency, and o the resistance in ohms of the inductive resistance placed as a shunt to the condenser. By making a shunt from this formula, the alternator current will be reduced to 0·075 ampere. In his experiments Mordey ought to have used no iron in his choking coil. The watt-hour meter used to determine the loss did not read correctly with the low power factor for reasons stated in a paper of March 24, 1893, in the *Electrical Engineer*. The losses he had found in condensers gave a power factor of 0·01 instead of Mordey's value of 0·124. **C. P. Sparks** mentioned that the capacity loss can be diminished by energising a minimum number of cables. A paper cable would have diminished any inconvenience from capacity by one-third. Five and a-half miles of concentric rubber cable having 0·86 mf. capacity from inner to outer and the outer earthed, with insulation of 6,000 megohms per mile, at a periodicity of 100 and a pressure of 2,000 volts, showed a loss of 1,509 watts in the cable alone, 530 watts in Mordey's choker alone, and 495 watts in choker alone with the keeper on. The meter revolved in one direction when connected to the cable and in the reverse when connected to the choker. To check these (Mordey's) measurements, a cable was tested by measuring the difference of power required to drive an alternate-current generator driven by

a direct-current motor. It was then noticed that the wave form of this generator caused the capacity current to be 2·1 times higher than it would have been with a sine wave, and eventually the power factor obtained with a sine wave was 0·04. Mather had re-tested the particular cable tested by Mordey. Ayrton's choking coil weighed 80 lbs., and the current in the alternator was 2·7 amperes; the power factor came out at 0·034. **J. A. Fleming** recalled that D'Alton had measured the power wasted on the Deptford scheme by taking careful indicator diagrams of a single engine both before and after it was connected to the capacities of the cable; the current was about 45 amperes at 10,000 volts; the power factor was nothing like 12 per cent. but may have been 2 per cent. **W. E. Sumpner** pointed out that the magnitude of the cable loss ought not to be considered in itself, but as compared to the load the cable is intended to transmit. The loss in the choker was likely to be about 4 to 6 per cent., and as against 2 per cent. which the speaker thought was the correct figure for the dielectric loss, therefore the choker loss was more important. A wattmeter may read accurately on a circuit of low power factor, say 0·02 if the circuit carries a lagging current, yet the same instrument may read wrong and even negatively if the current is a leading one. Particulars of the test on Mordey's wattmeter were therefore required, and he believed Mordey must have had a transformer in connection with his wattmeter and the difference in phase of 4 or 5 degrees between the primary and secondary circuits might produce the extraordinary results when the transformer is used for tests depending on phase. **J. Swinburne** expressed the opinion that the loss in cable dielectrics being continuous is important, even if small in comparison with the carrying capacity of the cables; it probably varies with temperature. The dielectric loss is probably a C^2R loss and has been rashly called *hysteresis*, for condensers in series with resistances show apparent "dielectric hysteresis." Insulators that heat most are those whose specific capacities are abnormally high in relation to their refractive indices, and this would tend to show that there is a molecular conduction, or paths of low resistance, the paths having lengths of the order of the dimensions of molecules. **T. Mather** objected to the general conclusion of high power loss, and considered that recording wattmeters are inaccurate at low power factors. He recommends as a convenient method of measuring the losses in a dielectric the use of an ironless choker of suitable inductance for bringing the current in phase with the volts. The coil losses are very closely the C^2R losses and the difference between the C^2R and wattmeter readings gives the loss in the cable. (See Ayrton, Electrician, Jan. 18, 1901; Mather, Electrician, Jan. 25, 1901; Rosa and Smith, Phys. Rev. Vol. 8. pp. 1–20, 1899.) The losses found on long cables were as follows :—

	P.D. in volts.	Frequency.	Power factor.	Maker.
Oiled paper, low-pressure cables tested at 2,000 volts	2,017	100	0·024	B. I. W. Co.
Jute	2,030	71·5	0·027	Callender Co.
Indiarubber	2,000	105	0·028	Silvertown.
Indiarubber (same as tested by Mordey	2,230	100	0·029	Do.
Indiarubber (Mordey's test)	2,040	100	0·124	Do.

The effect of wave form on the number of volt-amperes taken by a cable is important; they vary by 50 per cent. with the load on the alternator, and by 58 per cent. according to the alternator used. **M. O'Gorman** stated

that the loss of energy in a condenser or cable dielectric depends approximately on the square of the potential difference applied between the sides of the dielectric in question. Hence the energy lost depends on the distribution of potential within the thickness of the insulation, and this in turn depends on the grouping of the material in the various layers which constitute the insulation. In rubber cables the specific capacity of the layers is extremely irregular in oil and paper, and oil and jute fairly so. He gave a diagram of the potential distributed across a cable insulation to show that the energy loss may be six times greater with heterogeneous than with homogeneous insulation, unless the specific capacity of the insulation in the heterogeneous case is scientifically graded. Explanation is given of the greater loss when the curve of alternations is peaky. **W. E. Gray** would undertake to make rubber cables of any capacity, but this is different from guaranteeing that the capacity will not vary very considerably when the cable is ageing. **R. Threlfall** objected to the term dielectric hysteresis; even the ohmic resistance of a substance varies under the electric intensity of the test. Arnó and Steinmetz could not have deduced "hysteresis" from an experiment from which conductance loss was not eliminated. There is only a slight relation between the absorption of a condenser and the heating losses when it is supplied with an alternating current having a frequency of 30 or 40 per second: nine-tenths of the so-called absorption losses are due to spreading over the surface of the dielectric beyond the armatures, and the air-discharges between the armature and the dielectric surfaces. By eliminating air and moisture the losses may be reduced enormously. With paraffin oil and vaseline on pure cellulose paper applied under a vacuum it was reduced to nearly 0·1 per cent. He objected to the proposal to measure the work done by the square of the electric force. It was to be measured by some power between 1·5 and 1·9, and it only reaches the square with a heterogeneous dielectric such as he had made with paraffin and graphite. **T. H. Minshall** tabulated: (1) the effect of wave form on the quantity of capacity current, (2) the power factors of cables with different wave forms, and (3) the effect on the capacity current of a small load at the end of a cable. He had obtained a power factor of 0·1 on a cable whose insulation resistance was low, and this confirmed Mordey's test. **H. M. Sayers** pointed out the advantage of using iron core chokers for portable cable testing sets. He anticipated trouble from resonance as frequency is reduced. He endorsed O'Gorman's remark that the slope of potential in each layer is inversely proportional to the specific capacity, and suggested that the loss in multiphase cables may have been due to the fibrous packing and layers of air between the individual cores. If the dielectric power factor increases faster than the pressure, this may be due to heterogeneity. The cost of running a generating set in practice and producing only displacement current is about 20 per cent. of the cost of running it loaded. **W. B. Esson** considered that capacity in cables was a blessing in neutralising to some extent the lagging current always present in a general scheme of distribution. In the Power Bill schemes, the long lines will give a high capacity, but the power circuits will give rise to a correspondingly large lag. He did not think that sensibly larger engines would be required to supply the wattless current. **E. Wilson** suggested a method of measuring the dielectric power loss by means of two wattmeters with their moving systems coupled together. **A. Russell** pointed out that a very small variation from the sine wave-form of current considerably modifies the balancing action of condenser and choking coil. **G. H. Nisbett** corroborated Ayrton and Mather's tests on British Insulated Wire

cables, and, assuming that the dielectric loss given by Mordey should be divided by 15, works out the loss of power which will occur in the system projected by the Midland Power Company; taking the load-factor at 12½ per cent., the loss would be 0·4 per cent. **E. G. Cruise** gave details of two three-phase, three-core, high-tension cables, and showed that the percentage loss of power in the dielectric was far less with such cables than with single-phase concentric cables. **A. Whalley** gave three sets of e.m.f. and current curves of one alternator when working on a transformer load, on a a capacity load, and on a load of capacity in resonance with a choking coil. These curves show that, before using the coil, it is important to know the peculiarities of the alternator on a capacity load. **L. Andrews** agreed with Mordey in thinking that the generation of the charging current may be a serious expense. At Hastings, between midnight and 4 p.m. during last year, the output in volt-ampere units was as follows: useful work, 94,600 units; exciting transformers, 35,000 units; capacity current, 58,400 units. He reckoned that the cost of generating the capacity units was between £300 and £400. **W. E. Ayrton** gave particulars of the ironless choking coil made by Mather to replace Mordey's; its weight was about one-third of the latter's, and the power wasted in it three-fifths, while the current in the mains was reduced to a lower value. He then examines the conditions which give a negative deflection on a wattmeter when applied to measure a capacity current. **Mordey,** in reply, mentioned a communication from Kapp, who has found high-tension, three-phase cables appreciably warm on light loads, indicating a considerable dielectric loss. This is confirmed by several other cases of dielectric loss, verified, not by wattmeters, but by engineering methods admitting of no question; if Ayrton and Mather's measurements be correct, they merely show, as was pointed out by various speakers, that dielectric loss is a very variable quantity in different cables. Taking Ayrton and Mather's lowest figure for the true power factor, and applying this to several cases in actual practice, he shows that the loss is a large percentage of a supply company's profits. M. O'G.

2023. *Self-induction and Capacity in a Lighting Network with Concentric Cables.* **G. H. Julius.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 537–557, 1901.) —The author made measurements on the network of the Société Anonyme Belge Éclairage Électrique de Saint-Pétersbourg. Eight concentric cables, with rubber insulation, and a total length of 21·4 kilometres, were available for measurement, and from these the author found the dielectric constant of the rubber to be 3·8. From this figure the total capacity of all the high-tension feeders, of a total length of 243 kilometres, was calculated as 87·8 microfarads. The charging current of these cables at 2,000 volts and 42·5 ∿ is 46·8 amperes. Experiments made on the eight feeders mentioned showed that the charging current increased rather more rapidly than the pressure.

The transformers connected to the network are 950 in number, of a total capacity of 8,423 kw., the units varying in size from 0·75 kw. to 40 kw. The author made a large number of measurements on these transformers, which are given in a table at the end of the paper. The total open-circuit loss is 237·5 kw., and the total wattless current is 241·5 amperes. Combining these figures with those obtained for the capacity of the cables, the current at no load is calculated to be 228 amperes, with a power factor of 0·52, while without the cables the current would be 270 amperes and the power factor 0·44. To bring the capacity and self-induction into complete balance,

the capacity of the cables would have to be quintupled. At full load, the effect of the self-induction is negligible, the power factor being 0·991.

G. H. B.

2024. *An Artificial Forty-mile Transmission Line.* **W. S. Aldrich** and **G. W. Redfield.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 451–473, June and July, 1901.)—The artificial duplication and test of a forty-mile transmission line was carried out in the Electrical Engineering Laboratory of the University of Illinois. A fairly complete investigation is given of the effect of varying the magnitude and power factor of the receiver loads on the regulation and efficiency of the system. It is stated that the ohmic loss in the line according to the best modern practice is from 5 to 10 per cent. at full load. Step-up and step-down three-phase transformers are used and it is assumed that the efficiency is to be at least 80 per cent. at full non-inductive load. The external characteristics of the Westinghouse three-phaser for lagging and leading currents are found and diagrams illustrating the relation between the charging current and the resonant rise on the line, &c., are given. These diagrams verify Perrine's formula [see Abstract No. 2325 (1900)]. A diagram is given illustrating how the ratio of transformation of a transformer varies with the power factor of the load. It is found that the secondary volts rise as the phase difference between the secondary e.m.f. and current diminishes, and continue to rise when this becomes negative. The experiments illustrate the paramount importance of keeping the capacity currents of the mains as small as possible. Interesting oscillograph pictures of the wave forms at both ends of the line are given. They show that the bad regulation of the earlier systems was due to wave-form peculiarities owing to the various types of generators, &c., used. It is proved that when synchronous motors or converters are used giving wave forms unlike those of the impressed e.m.f., then the regulation is very bad and the machines easily fall out of synchronism.

A. R.

2025. *Direct-current Engineering Practice in Germany.* **C. Brandeis.** (Elect. World and Engineer, 38. pp. 11–13, July 6, 1901.)—The great majority of German central stations use shunt-wound dynamos in conjunction with storage batteries, even for electric traction. Thirteen diagrams are given, showing various systems of working in common use ; the one generally preferred for the three-wire system employs two batteries, with regulating end-cell switches next to the neutral wire, a single motor-driven booster for charging them, and the main generators coupled across the outers.

A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2026. *East Ham Combined Lighting and Traction System.* (Tram. Rly. World, 10. pp. 333–343, July, 1901.)—This is the first municipal tramway scheme in the Metropolitan district. The length of line contemplated is $9\frac{1}{8}$ miles, of which $4\frac{1}{2}$ miles are completed. The total estimated cost for the tramways is £89,900, and for lighting £47,970. The engine room is 177 feet by 42 feet with 26 feet clear height, and is spanned by a 20-ton traveller. The boiler house is 148 feet by 46 feet and has a main flue 12 feet by 6 ft. 3 in. leading into a circular stack 9 ft. 4 in. diameter by 135 feet high. The engine room now contains one 100-kw. and three 225-kw. sets of Musgrave horizontal cross-compound engines direct coupled to the generators. The small engine

has cylinders 9 inches and 18 inches, and stroke 24 inches, speed 150 r.p.m. The large engines run at 135 r.p.m. with 27 inches stroke, and cylinders 13½ inches and 27½ inches.

For traction the generators are used compound wound for 500–550 volts. For lighting they are used as shunt wound and field regulated to 480–580 volts. Two balancers, each capable of dealing with 100 amperes of out-of-balance current, are provided for the three-wire lighting mains. There are four Babcock boilers, each evaporating 10,000 lbs. per hour, fitted with Babcock superheaters. A Boby heater detarteriser is used; also a Barnard-Wheeler condensing tower and two Wheeler condensers available for any engine.

The cables are single, lead covered, by Callender. The track is laid with 87-lb. rails to standard gauge, bonded with 4/0 S.W.G. Neptune bonds. Double track is laid on a continuous bed of 6-inch cement concrete, paved to 18 inches outside rails with granite setts. Single track is laid on a similar bed of concrete 9 inches thick and paved with setts 9 inches outside each rail with tarred macadam in the centre. Sykes' patent conduit, with self-centring Stanford joints, is provided throughout under the centre of track with draw-in boxes every 100 yards. All lighting and traction feeders are carried in this conduit. The overhead trolley wire is 0 B. & S. carried on side and bracket-arm poles, the maximum length of bracket being 18 feet. Poles are 31 feet long and weigh 990–1,320 lbs. without bases. The car equipment is of standard "Short" design with two motors per car, each giving 1,000 lbs. tractive effort at 10 m.p.h. The controllers have rheostatic brakes.

E. H. C.-H.

2027. *Luton Electricity Works.* (Electrician, 47. pp. 435–437, July 12, 1901.)—This continuous-current station contains two Lancashire boilers, 30 feet by 8 feet, with superheaters; an economiser of 240 tubes; three 85-kw. dynamos; a 42-kw. balancer; a 16-kw. dynamo for charging the regulating cells; 280 chloride cells, giving 70 amperes for seven hours. The chimney is 120 feet high, with internal area of 60 square feet, and firebrick lining to a height of 40 feet. Two feeders have been laid, one 0·3 square inch, and the other 0·2 square inch in sectional area. A plan and sectional elevation of the station are given.

W. H. S.

2028. *Southend Electric Tramways.* (Electrician, 47. pp. 513–515, July 26, 1901.)—About 7½ miles of track have been opened, and extensions are contemplated. The power-house contains three Economic boilers, 14 feet by 8 feet, with heating surface of 1,180 square feet. The steam main consists of a single 8-inch pipe, and besides this each engine is fed by a 4-inch pipe from one boiler. The engine-room is 84 feet long, and 45 ft. 5 in. broad, and has a 20-ton travelling crane. It contains two 200-kw. dynamos, the engines being of the vertical cross-compound type, running at 110 r.p.m., with an 8-ton flywheel; and also a similar 125-kw. set, running at 360 r.p.m. The tramway track has a gauge of 3ft. 6in.; the rails weigh 92 lbs. per yard, and sole plates of inverted rail are used at the joints.

W. H. S.

2029. *Dresden Power Works.* **W. Meng.** (Elektrotechn. Zeitschr. 22. pp. 495–499, June 20, 1901.)—Dresden has three electricity stations. One in the eastern part of the town supplies 50 km. of tramways with power, and has 5,350 h.p. installed; another in the western part supplies alternate current for lighting, and has 7,600 h.p.; and the third, which is on the same site as the

second, supplies power to 70 km. of tramways, and has 6,000 h.p. available. The last of these stations is described in the present article. The engine-room is 68 m. long and 20 m. broad ; the boiler-house is 16 m. broad and 74 m. long. Coal is brought on a railway siding, and after passing four turntables is shot out of the trucks and conveyed by belts, elevators, &c., to the various bunkers. The bunkers hold 450,000 kg. of coal, and a subsidiary coal store holds a further 385,000 kg. At present there are sixteen boilers of the double-drum type, the one drum being placed above the other. Ten of these boilers are by Sulzberger, and have a heating surface of 112 sq. m. ; the remaining six are by the Dresdener Maschinenfabrik, and have a heating surface of 120 sq. m. The chimney is 70 m. high and 3·5 m. in diameter. There are five steam dynamos, each of 1,200 h.p. One set of engines, built by the Augsburger Maschinenfabrik, has cylinders of 750 mm. and 1,150 mm. diameter by 1,400 mm. stroke ; the other set, built by the Dresdener Maschinenfabrik, has cylinders of 775 mm. and 1,250 mm. diameter by 1,250 mm. stroke. The latter are slightly more economical of steam than the former, and take 5·6 kg. per i.h.p. hour on a load of 1,000 b.h.p. at 85 r.p.m., working with steam at 9½ atmospheres and a vacuum of 65 cm. The dynamos are shunt-wound, and work in parallel with buffer batteries. The Schuckert dynamos have 28 poles with a magnet bore of 5,515 mm. ; the Kummer dynamos have 18 poles and a magnet bore of 5,550 mm. Various points in connection with the condensers, cooling towers, feed-water heaters, oil-filtering arrangements, &c., are described in some detail. W. H. S.

2030. *Boston Electric Supply Stations.* **E. S. Mansfield.** (Elect. World and Engineer, 37. pp. 797–822, May 18, 1901.)—*System.*—Continuous current, three-wire, at a pressure of 250 volts on the outers, with storage batteries. The plant is installed in three generating stations and three battery substations.

Station No. 1, at Head Place.—The boilers are contained in a special four-story building. On the first floor are three Whittier return tubular boilers, each with 35 square feet of grate surface ; the second floor is used as an ash-room, the ashes from the boilers above being discharged through chutes ; the third floor contains five Babcock and Wilcox boilers, with 56 square feet of grate surface, having a nominal capacity of 285 h.p. each. A Sturtevant fan driven by a direct-coupled engine provides these boilers with forced draught. Feed-water, from the city mains, is supplied by steam pumps and Körting injectors ; it is heated to 210° F. in a Goubert heater. The fourth floor is a coal bunker of 250 tons capacity ; the coal is raised by an electric elevator. The *engine-room* is on the ground floor of a separate building, and contains nineteen Armington and Sims simple non-condensing engines, each of 150 h.p. at 260 r.p.m. The cylinder diameter is 15½ inches and the stroke 15 inches. The dynamos are on the first floor, two being driven by belts from each engine. They are shunt-wound, bipolar machines of 60 kw. each, built by the Edison General Electric Company. Each pair supplies the three-wire system at 250 volts on the outers. A three-wire booster set gives 75 kw. at 750 r.p.m. The second, third, and fourth floors of the building are devoted to offices.

Station No. 2, in Hawkins Street.—This station is similar to the first, having a boiler-house, with coal-bunker above it, adjoining a three-story engine-house. The *boiler-house* contains two Babcock and Wilcox boilers of 225 h.p., two Heine safety boilers of 260 h.p., and one of 164 h.p. The *engine house* contains 12 engines driving 24 dynamos on the floor above, the machines being of the same size and make as in the first station.

Station No. 3, in Atlantic Avenue.—Full details are given of the construction of the buildings constituting this station and of its two shafts. The *boiler-room* contains seven double-deck Babcock and Wilcox boilers of 368 h.p. each, and eight of 418 h.p.; the water-heating surface in the two sizes is respectively 2,680 and 4,181 square feet. They are provided with Babcock and Wilcox chain-grate stokers, worked by electric motors.

Feed-water is supplied by steam pumps and Körting injectors; it is heated first by a Goubert exhaust heater and next by a Cochrane open heater. The *engine-house* contains four 660-h.p. engines, each driving two 200-kw. generators; one 1,200-h.p. engine, driving two 400-kw. generators; two 1,200-h.p. engines, each driving one 800-kw. generator; and two 2,400-h.p. engines, each driving one 1,600-kw. generator. The 660-h.p. engines, by the J. Morton Poole Company, are vertical, triple-expansion, condensing engines; they run at 120 r.p.m. at a pressure of 160 lbs. per square inch. The cylinder diameters are $16\frac{1}{4}$, $23\frac{7}{8}$, and $38\frac{1}{2}$ inches, and the stroke 30 inches. Each has a Wheeler surface-condenser and a Knowles combined circulating and air pump.

The three 1,200-h.p. vertical cross-compound engines are by McIntosh, Seymour and Co., and run at 100 r.p.m. They have reheaters of 440 square feet surface between the cylinders; the guaranteed steam consumption is $13\frac{1}{4}$ lbs. per i.h.p. hour. The cylinders are 23 and 48 inches in diameter and 48 inches stroke. Each engine exhausts into a Wheeler surface condenser.

The two 2,400-h.p. engines are of similar type, by the same firm, and run at the same speed. The cylinders are 29 and 60 inches by 56 inches stroke; the guaranteed steam consumption is $12\frac{3}{4}$ lbs. per i.h.p. hour; the reheater has 800-square feet surface. The engines are provided with turning gear driven by 5-h.p. motors. The next units to be laid down will be 4,000-h.p. engines driving 2,500-kw. generators. The travelling crane of 50 tons capacity has a span of 81 feet.

All the generators are direct-driven, and, except the first four, are built by the General Electric Company. The 200-kw. machines give 1,333 amperes at 160 volts, running at 120 r.p.m.; the 400-kw. machines give 2,857 amperes at 140, running at 100 r.p.m. The two 800-kw. dynamos supply current to the outer wires only, giving 2,666 amperes at 300 volts, or 2,963 at 270 volts; their speed is 100 r.p.m.; their commercial efficiency is, at full-load, 93·5 per cent., and at half-load 90·5 per cent. The two 1,600-kw. machines run at the same speed as the 800-kw. machines, giving double the current; one machine is arranged to give six-phase current at 184 volts and 25 $\sim$. There are two three-wire General Electric booster sets, each of 75 kw., giving 1,360 amperes at 55 volts.

The main switches, some for 7,000 and others for 3,500 amperes, are opened and closed by electric motors.

The cables now laid extend over 53 miles of streets. As feeders, there are 127,000 feet of Edison three-wire 1,000,000 circ. mils. tube, 145,000 feet of cable of the same size, and 35,000 feet of cable of 350,000 circ. mils. As distributors, there are 301,300 feet of Edison three-wire tube, varying in size from 200,000 to 350,000 circ. mils. The cables in use are made by the General Electric, Habirshaw, New York Safety and National Conduit and Cable Company; the insulation is mostly rubber, but some cables are paper-insulated. The cable is all drawn into conduits, varying in size from 3 to 120 ducts; two kinds of duct are in use, the cement-lined duct of the National Conduit and Cable Company and the vitrified duct of the H.B. Camp Company.

Eight storage batteries are located at the different stations. At the Head Place station are two batteries; one is a Tudor battery of 144 cells, with

a discharge rate of 9,400 amperes for 1 hour, or 4,890 amperes for 3 hours; the other is a chloride battery by the Electric Storage Battery Company of Philadelphia, consisting of 150 cells and discharging at 5,600 amperes for 1 hour or 2,800 amperes for 3 hours. At the Hawkins Street station is installed a chloride battery of 140 cells, discharging at 4,000 amperes for 1 hour or 2,000 for 3 hours. At the Atlantic Avenue station are two chloride batteries of the same size as that at the Head Place station; the regulating switches are operated by electric motors, controlled by push-buttons on the switchboard. A battery station at Scotia Street contains a chloride battery of 144 cells of the same size, and a three-wire 60 kw. booster. A battery station at West Canton Street contains a Tudor battery of 144 cells, having a rate of discharge of 4,925 amperes for 1-hour, or 2,570 for 3 hours. At Pittsburgh Street is a battery of 140 chloride cells, with discharge rate of 3,040 amperes for 1 hour, or 1,520 for 3 hours. The total capacity of all the batteries amounts to 43,765 ampere-hours at a 1-hour rate or 65,647 at a 3-hours rate of discharge.

The meters used on consumers' premises are the Edison chemical and the Thomson-Houston; the Wright demand indicator is also in use. The connections to the mains are 243,800 16 c.p. lamps, or their equivalent, 2,430 arc-lamps, mostly of the Jandus type, and motors up to 100 h.p., with an aggregate of 10,400 h.p. A load diagram of the Atlantic Avenue station is reproduced. The article gives full details of all parts of the plant, and is illustrated by 53 diagrams and cuts. G. H. B.

2031. *Increasing the Pressure of Distribution at Niagara.* (Elect. World and Engineer, 38. pp. 94–95, July 20, 1901.)—The pressure at which the Niagara Falls Power Company transmits power to Buffalo has now been raised from 11,000 volts to 22,000 volts. This was contemplated at the start, and all the transformers were constructed for either 11,000 or 22,000 volts on their secondary terminals. [See Abstract No. 1193 (1900).] High-pressure circuit-breaking switches have been put in the lines before they leave the power-house. Formerly all the switching was done on the low-pressure side. These switches have a break of 4·5 feet, but this has proved insufficient, and is to be increased to 6 feet. Westinghouse "low equivalent" lightning arresters are used. As the storms are very severe, elaborate devices have been found necessary. The arrester consists first of six choking coils in series, then a 36-inch enclosed fuse of No. 28 German silver wire, and then 61 gaps between non-arcing metals, one of the gaps being adjustable. Finally, the discharge has to pass through two non-inductive coils in series of 380 and 280 ohms resistance respectively, the former being shunted by 48 gaps in series. The flow of current during a discharge through the 380-ohms coil is sufficient to create a p.d. which breaks over the 48 gaps. The adjustable gap is generally fixed at $\frac{3}{8}$ths or $\frac{1}{2}$ an inch, and the other gaps at $\frac{1}{32}$nd of an inch. The use of fuses in this kind of arrester is peculiar to the Niagara plant. A wire heavily insulated with rubber, $\frac{5}{32}$nds of an inch thick, which withstood a testing pressure of 50,000 for ten minutes, broke down after a week of continuous service at 22,000 volts. It is suggested that this was due to the continuous brush discharge from the wire at certain points generating sufficient ozone to rapidly deteriorate the rubber. A number of insulators on the line have proved too weak for the higher voltage. These are weeded out by patrolling the line at night and noting the burning pins. Repairs are made in the daytime when the current is off the line. Interesting photographs are given of a 22,000-volt ammeter panel, and also of the high-pressure bus-bar arrangements. A. R.

2032. *Distribution of Energy at Buffalo.* **H. G. Stott.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 237–264, April; Discussion, pp. 381–391, June, 1901. Also Elect. World and Engineer, 37. pp. 516–519, March 30, 1901.)—The author gives much important information concerning the detail work of distributing power from the Niagara Falls in the city of Buffalo. [See also Abstracts Nos. 1192 and 1193 (1900).] Various types of high-tension switches and circuit-breakers are described; for the details the original paper should be consulted. The five cables for distributing power at 11,000 volts from the main station in Buffalo have each of them three conductors, of 000 B. & S. gauge. Three of these cables are insulated with a wall of rubber mixture $\frac{9}{32}$ inch thick, having 30 per cent. pure Para rubber; one has a wall of $\frac{1}{4}$ inch rubber mixture with 40 per cent. pure Para rubber; and the fifth has on each conductor $\frac{3}{64}$ inch of paper, and around the three insulated conductors an additional belt of $\frac{3}{64}$ inch of paper. The three insulated cables are twisted into a rope, and the interstices filled with jute yarn, to give an even surface for the lead, which is $\frac{1}{8}$ inch thick. The outside diameters of the cables are approximately $2\frac{3}{8}$ inches for the rubber and $2\frac{5}{8}$ inches for the paper cables. Experience shows that the first three cables are good for 11,000 volts; the fourth apparently is not; while the paper cables have been laid too recently for any conclusions to be possible. In the discussion some of the speakers drew attention, from the manufacturing point of view, to the figures given for the insulation of rubber cables. The author, however, stated that an extra thickness of $\frac{1}{32}$ inch of insulation had greatly decreased the number of breakdowns. He stated that tests were being made with a view to finding out what deterioration of insulation took place under continued high pressure. If at the end of ten days the insulation resistance is 400 megohms, at the end of twenty days it may be down to half that value, and keep on decreasing. The decrease in the case of pure rubber appears to be more marked than in the case of less pure rubber, but the tests are as yet incomplete. In the runs of the various cables above mentioned, oil switches are placed about a mile apart in water-tight iron boxes for the purpose of isolating a defective length. The cables are looped and not tapped into the substations; this enables cross-connections to be made in case of a failure. The largest user of power is the International Traction Company, which receives 7,000 h.p. at 11,000 volts, and transforms by rotary converters to 600-volt direct current. The author states that for 200-kw. units the efficiency of rotary converters and static transformers combined is 3·27 per cent. higher than that of synchronous motor-generators at full load. Moreover, they are about 19 per cent. cheaper. Figures are also given comparing the efficiencies at other loads, at half-load the rotaries having an advantage of 5 per cent. For railroad work, "where no great refinement of regulation is required, the rotary is beyond doubt the best and most economical." There is also a large substation where current is supplied to the Buffalo General Electric Company, and by them converted and distributed in a variety of ways. They undertake the street arc-lighting; for this purpose the present method adopted is to use 14 motor-generator sets, each consisting of a 150-kw. synchronous motor coupled to two 125-light 9·6-ampere Brush arc generators. They also distribute 60-cycle current for incandescent lighting by means of synchronous motor-generators, the generators giving current at 2,200 volts. The difficulties involved in synchronising these machines were rather unusual, owing to the fact that the motors had 8 poles and the generators 20. These were partly overcome by the insertion of a reversing field switch on the motor, which caused it to slip a pole on each reversal. Other precautions

had to be adopted in the matter of excitation to ensure that the two machines, when paralleled, should properly divide the load.

Discussion.—The question was raised as to the applicability of three-phase current to traction work. **Steinmetz** said that he had started testing a three-phase trolley-car in 1894; he considered the three-phase motor decidedly inferior in starting, and in running at low speed, and in acceleration, to the continuous-current series motor. The motor is in its electrical and mechanical character essentially a shunt motor. At starting, the same current is required for a given torque as is required at full speed; the rest of the power corresponding to the reduced speed is merely wasted in the rheostat. The power factor of induction motors would be much decreased in practice, owing to the necessity of using motors with large air-gaps for mechanical reasons. This would increase the reactance drop on the line, and might cause such a fall in voltage that the induction motor, the torque of which is proportional to the square of the voltage, might not start at all. Moreover, even at 20 cycles, the ordinary iron rail offers against an alternating current an impedance which is from three to five times the ohmic resistance. Regarding circuit-breaking devices, he pointed out that a break in air is essentially a quick break. Metal vapour can draw an arc two or three feet long, having a drop of not more than a few hundred volts across the arc; but when the break takes place, it is extremely quick. With an oil switch the break is not a quick break. Liquid is practically incompressible; the gas bubble which is formed stands under enormous pressure, and holds the arc up to the next zero value of the current, when the liquid pressure blows out the arc. In all inductive circuits with negligible capacity the air switch is more dangerous than the oil switch; and this is probably true generally. W. H. S.

2033. *Spanning Carquinez Straits with a High Potential Transmission Line.* **R. H. Sterling.** (Elect. World and Engineer, 37. pp. 963–966, June 8, 1901.)—This paper contains a general description of the method adopted by the Pacific Construction Company of San Francisco in the construction of an aerial cable across these straits, to be worked at a pressure of 60,000 volts. The channel is 3,200 feet wide, and Government requirements called for a clearance of 200 feet above high water, which, with the sag of 100 feet allowed, necessitated the construction of towers 65 feet and 225 feet in height respectively. The span between the supporting towers is 4,427 feet. A wind pressure of 75 miles an hour had to be provided against. The cable employed was a stranded steel wire $\frac{7}{8}$ inch in diameter with a breaking strain of 98,000 lbs., the total weight of each span being 7,080 lbs. The tension on the cable when *in situ* was such as to allow a factor of safety of 4. Cast-iron saddles on wooden platforms and porcelain insulators take the cables on top of the towers, the ends being fastened to "strain insulators," of which the draw-bars are insulated from the steel yokes by micanite and an oil chamber, with a porcelain sleeve in paraffin to prevent creeping. Two strain insulators are used in series. Four cables are suspended, one being a reserve to the three-phase system employed. The author notes that when a cable is switched out for repairs it must first be earthed, as the static effect is great. The strain insulators and anchorages are protected by enclosing shelters. The paper is illustrated with detail drawings and photo blocks of the two types of insulator employed.

A very complete account, with drawings and illustrations, also appeared in the Journal of Electricity S.F., May, 1901. B. P. S.

2034. *The Kensington and Notting Hill Companies' Joint Electricity Supply Works.* (Electrician, 47. pp. 738–743, Sept. 6; 779–781, Sept. 13; and pp. 818–820, Sept. 20, 1901.)—The station, which has been erected by the two Companies for the supply of energy to their already existing systems, is situated at Shepherd's Bush, and immediately adjoins the station of the Central London Railway Company. It is at some distance from the areas to be supplied, and therefore the three-phase alternating-current system was selected. This is to be converted to continuous current by means of asynchronous motor-generators, each of the two Companies making its own arrangements for this conversion. The site of the power station adjoins several railways, from which extensive sidings have been constructed, amounting in all to a length of 1,400 feet. Both the boiler-house and engine-room are 126 feet long by 45 feet wide, the 20-ton travelling crane being 28 ft. 6 in. above the level of the engine-room floor. The chimney is 230 feet high and 11 feet in diameter; it stands on a concrete block 36 feet square and 10 feet thick. The firebrick lining is carried up to a height of 40 feet from the bottom. The lightning conductor consists of two copper bands $1\frac{1}{2}$ inches by $\frac{1}{8}$ inch, terminating in four copper earth-plates, and round the top of the cap there are six gold-plated copper points with a copper ring. The boiler-house contains at present five boilers, each having a heating surface of 3,654 square feet, working at a pressure of 200 lbs.; they are fitted with chain-grate stokers. The main flues are in duplicate, and each contains a 320-tube economiser. The coal and ash handling plant is described in detail. It was constructed by Graham, Morton & Co., of Leeds. The coal is first raised by an elevator through a height of 75 feet, and is then distributed by a push-plate conveyor to the various bunkers. These bunkers are placed above the boilers, and are 108 feet long, 17 feet wide, and 17 feet deep, being capable of storing 800 tons of coal. From the bunkers the coal is fed into the boilers by means of shutes. The whole plant is designed to deal with 30 tons of coal per hour. Over the boilers are two cast-iron water tanks, holding 55,000 gallons of water. They measure 112 feet by 16 feet by 6 feet, and are placed at such a height that they give the head of water required by the ejector condensers fitted on the engines. The steam pumps are six in number, and are of the Karoome type; three are feed pumps, having a capacity of 4,000 gallons per hour; and three are low pressure pumps, dealing with 100,000 gallons per hour against a 35-feet head. A cooling pond, working on the jet system, has been constructed; it measures 100 feet by 60 feet by 7 feet. The main steam-pipe is 7 inches in diameter; the T-pieces are of wrought steel riveted to the pipes. The engine-room contains at present five steam alternators. Of these, three have a capacity of 330 kw., running at 300 r.p.m., and two others generate 550 kw., running at 270 r.p.m., the voltage being 5,250, and the frequency 45. The engines are by Willans, and the alternators by the Oerlikon Company. The engines are of the three-crank triple-expansion type, and each is fitted with a Koerting ejector condenser. The engine cylinders are lubricated by a mixture of graphite and cylinder oil, which forms a thick paste, one drop per minute being fed into the engine cylinder. The generators are of the inductor type and give three-phase current. In the case of the smaller machines, the inductor is 1,814 mm. in diameter, and the clearance between rotor and stator is 3 mm. The exciting current is provided either by exciters, or a motor-generator, or by a battery, the latter consisting of 56 cells, having a capacity of 600 ampere-hours. The cells and the motor-generator are used for working

auxiliary motors in the station and also for lighting purposes. The switchboards are in five separate sections ; the first panels are for the exciters, cells, &c. ; the second for the smaller alternators and the motor-generator ; the third for the trunk mains to the Notting Hill Company's district ; the fourth for the larger alternators ; and the fifth for the trunk mains to the Kensington Company's area. Care has been taken to make the switchboard as safe as possible. All working parts are placed behind the board, each panel having a cage of iron wire-work behind it, the door of which is closed with a Yale lock. In case anything should require adjustment, the engineer-in-charge has to cut off the current from the panel by means of the main switch, and lock it with a Yale lock, after which access is possible to the cage at the back of the panel in question. In this way, no parts carrying high-tension current are exposed on the front of the board, the main switches being operated from the front, but having their working parts at the back of the board, and at a considerable height above the floor level. The feeders to the sub-stations are all composed of conductors having a section of 0·15 square inch, and are in all cases connected to asynchronous motor-generators. The Kensington Company has a sub-station behind the Albert Hall, containing one 100-kw., two 180-kw., and three 200-kw. machines. Motor-generators have also been placed in the Kensington Court Station. The Notting Hill Company has a substation on the site of their main station in the High Street, Notting Hill, and also another in Lancaster Road. The first contains two 60-kw., two 180-kw., and one 300-kw. motor-generator ; while the second has one 100-kw., and one 180-kw. sets. All the machines run at speeds between 380 r.p.m. and 420 r.p.m. The main power-house at Shepherd's Bush contains the usual workshops ; into these a railway siding is brought, and a 10-ton overhead traveller is provided for the purpose of unloading and handling machinery. There is also a complete set of apparatus for testing coal, and for carrying out boiler trials. The article contains several drawings, showing plan and section of the generating station, the general arrangements of the switchboards at Shepherd's Bush and at the Lancaster Road substation, and also the general construction of the alternators ; in addition, there are illustrations of the coal-handling appliances, and of several points in connection with the switchboards. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

2035. *Electric Railways.* **P. Cardew.** (Soc. Arts, Journ. 49. pp. 641–651, July 12 ; 653–662, July 19 ; and 665–674, July 26, 1901.)—On tramcars the use of gearing is universal ; on trains the best method of driving is still doubtful. One of the most hopeful proposals is that of Ganz, who mounts the motor armature on a hollow cylindrical axis normally concentric with the solid axle of the wheels, but carried by the underframe of the motor car, which is spring-supported in the usual way. The hollow axle has three projections symmetrically disposed, to two of which connecting rods are attached, while the third is for balancing. The connecting rods are attached at their other ends to bell cranks pivoted on spokes of the driving wheel, and these bell cranks are connected by a third rod. The whole jointed system transmits the torque from the hollow axle to the wheels, while allowing considerable relative motion vertically between the two axles.

The second lecture deals with the polyphase system and describes the

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

form installed by Ganz on the Lecco-Colico lines and proposed for the London Underground. The "cascade connection" consists in joining the rotor of the main motor to the stator of a second motor. The large rotor then generates currents in the small stator at a frequency proportioned to the slip, *i.e.*, starting at the frequency of supply and becoming slower as the motors speed up. If the small rotor is connected to an external resistance it will generate current at a frequency proportional to its slip. If the motors are mechanically connected (as in the Ganz system), and if the common speed at which they must move is one-half the synchronous speed for the large motor, then the slip of the large motor is 50 per cent., the frequency of the current supplied by it to the second motor is one-half that of the supply current, and the slip of the small motor is zero. Two motors thus coupled tend to a limit of half speed, like two continuous-current motors in series, except that in the latter case each motor receives half the energy directly from the supply, whereas in the former case the whole energy is taken by the stator of the first motor and transmitted inductively to its rotor, which applies one half mechanically to the axle, and transmits the other half electrically to the second motor.

To accelerate from half to full speed it is not practicable to put the two motors in parallel, but a rheostat is substituted for the small motor. With Ganz's arrangement, considering merely the acceleration of the mass of a train, the maximum power taken is proportional to the rate of acceleration and the maximum speed required. Also the total energy required varies as the square of the speed attained, and is independent of the acceleration.

With the cascade arrangement, braking action with return of energy to the line is available from full speed down to nearly half speed. The amount of energy returned is about 16 per cent. of that used for acceleration on the level, or about 30 per cent. of the kinetic energy of the train, thus making the efficiency of the system undoubtedly greater than is obtainable with the series-wound continuous-current motor.

Low frequency is found advisable with the cascade system. Ganz uses 15 periods and proposes to avoid difficulty with blinking lights by using a three-filament lamp, so that the average brilliancy of the three filaments is constant.

The control in the Ganz system is all effected by compressed air, to avoid dangers of shock. The rheostat is cut in and out by compressed air controlled by an automatic valve, which can be set for a predetermined rate of acceleration. The rheostat consists of iron plates up which alkaline solution is forced, the plates being so shaped that the immersed surface rapidly increases as the liquid rises: this maintains the starting torque uniform up to full speed.

The compressed air system allows the control of several pairs of motors from one end of the train on the multiple-unit system.

The third lecture deals with generation and transmission, discusses the relative advantages of continuous and polyphase current, and works out the traffic arrangements, equipment, and cost of a railway which might advantageously adopt electric traction. The lines consist of two Metropolitan termini serving one main line, with local loops at the Metropolitan end and branches at the seaside end, 50 miles from London. E. H. C.-H.

2036. *Graphical Solution of Electric Traction Problems.* **G. Brandt.** (Elektrotechn. Zeitschr. 22. pp. 514–515, June 20, 1901.)—A letter criticising Pforr's paper [Abstract No. 1844 (1901)] on this subject. The author is of

opinion that the apparent simplicity of some of Pforr's diagrams is due to his having made assumptions which are not fulfilled in practice; and that if all the conditions of practical working were taken into consideration, the graphical method would in general be much too complicated to be of value.
A. H.

2037. *Trolley and Bow Collectors.* **R. Philippe.** (Génie Civil, 38. p. 225, 1901.)—This paper compares the advantages of the trolley and bow forms of collectors for tramways. Some forms of bows are illustrated: a brass bar, covered with white metal, lasts about a fortnight; when provided with a groove containing grease its life is from six weeks to two months. One form shown consists of two U-section aluminium channels placed one inside the other; the interspace is filled with grease and the centre channel with white metal. The triangular form of bow with lateral flexibility is recommended, as this regains its proper position if it escapes from the trolley wire without breaking contact. The bow is not liable to jump off the trolley wire at crossings and curves, and allows greater latitude in the overhead construction than the trolley.

The pressure of the bow against the trolley wire need not exceed three to five kilos, while the trolley requires a greater pressure to prevent jumping. The wear on the trolley wire with a bow collector flattens the lower surface; as the rubbing surface increases the pressure per unit of surface, and consequently the wear, diminishes. After four years the wear on an 8 mm. wire amounted to only 5 per cent. The wear occasioned by a trolley wheel is considerably more, and is chiefly on the sides of the wire. G. H. B.

2038. *Methods of Safety for Overhead Systems.* **E. Manville.** (Tram. Rly. World, 10. pp. 372–375, July, 1901. Paper read before the Association of Municipal and County Engineers, at Leicester, June, 1901.)—Formerly 0 B. & S. trolley wire was used, breaking at 4,560 lbs.; this occasionally parted, and a gradual strengthening of overhead construction has taken place, till 000 wire is now the best practice. This stands a strain of 6,580 lbs. Guard wires should be of galvanised steel not less than $\frac{3}{8}$ inch diameter, supported substantially. The latest Post-office regulations describe a good arrangement, and are discussed by the author in detail.

Stops on the trolley arm make it difficult to foul the guard wires; but if this does happen the trolley head is almost certain to be torn off. Hence the trolley pole should be long enough to allow the head to fall clear of the car. All metal parts of the car should be carefully earthed to avoid shocks.

Devices to ensure safety in the event of breakdown are either (i) automatic switches requiring a pilot wire for each section of trolley wire, carried the whole length of the $\frac{1}{2}$-mile section; or (ii) mechanical devices. The best of the former is the "Quin" switch, which involves isolating adjacent sections of trolley wire, and also necessitates hand operation of the switches in each pillar after supply has been cut off by accident or at night. The mechanical device usually consists of a short weighted lever, which drops into contact with the bracket arm or other "earth" in the event of fracture of the trolley wire. E. H. C.-H.

2039. *Friction of Brake Shoes.* **R. A. Parke.** (Railroad Gazette, 33. pp. 404–408, June 14, and 435–438, June 21, 1901.)—The old law that friction between two surfaces is merely proportional to the force with which they are pressed together, and is increased by adhesion at rest and decreased by

lubrication, was proved inadequate by the Westinghouse-Galton experiments in 1878. The conclusions from these were admittedly limited, but further experiments were not published till a paper was read before the Western Railway Club in September, 1900, based on experiments with the Master Car Builders' brake-shoe testing machine. This paper concluded that—

(i) The coefficient of friction decreases as the pressure increases, within the limits of the tests.

(ii) The coefficient decreases with increase of speed, except from ten to twenty miles per hour, between which points it slightly increases.

(iii) The coefficient is generally nearly constant from shortly after the start till just before the stop, when it rises from $1\frac{1}{2}$ times to twice the average value.

The author criticises each of these conclusions at length, agreeing with (i) which falls in with the idea of friction being due to the irregularities of the two surfaces being more or less interlocked according to the pressure. Conclusion (ii) he considers wrong, being founded on a comparison of the values of the "mean" coefficient of friction during stops made from various initial speeds. This mean coefficient bears somewhat the same relation to the actual that the mean effective pressure of a steam diagram does to the actual pressure at any moment. He considers that the relation is of the form—

$$f' = \frac{a}{1 + bV};$$

where f' = coeff. of friction, V = speed, and a and b are constants for the materials and conditions. Conclusion (iii) should rather read: "In an application, during which a uniform speed is constantly maintained, the line representing coefficient of friction rises quickly to a maximum, and then immediately declines with a continually decreasing rapidity, until it reaches a certain level (considerably below the initial maximum), at which it thereafter remains practically constant."

Further criticism is made of temperature observations, which were not taken at the surface of the shoes, and are therefore worthless, owing to varying rates of conduction.

The second part of the article deals at length with the nature and scope of desirable experiments on the subject. E. H. C.-H.

2040. *Brakes for Electric Tramcars.* **A. L. C. Fell.** (Elect. Rev. 49. pp. 120–121, July 19, 1901. Paper read before the Municipal Electrical Association at Glasgow.)—The author describes and criticises the various forms of brake. For general purposes, the hand-brake worked in conjunction with the slipper-brake gives the best results. The author considers that the "Corning" brake-shoe is the best; it is more expensive than the ordinary cast-iron shoe, but lasts much longer, without materially affecting the wear and tear on the wheels. A Corning shoe was shown to the Association, which had run over 12,500 miles on a route where the gradients reached 1 in 11, and would have easily lasted over another 1,000 miles. Ordinary cast-iron shoes over this route ordinarily last for 6,000 miles. Fricton-plate brakes are simple and effective, but are not much used owing to their taking up too much space. Slipper-brakes constitute a most useful type, consisting of wood blocks pressed on the rails by levers, and they should be used on all gradients steeper than 1 in 20, the best results being obtained when they are used in combination

with a hand or electric brake. Pneumatic brakes are both complicated and unsatisfactory; the dust which is drawn in with the air cuts up the cylinder of the compressor, and there are points in connection with the design and working of the apparatus which require further attention. There are also various forms of magnetic brake, including the Newell, which is a form of slipper-brake, giving satisfactory results under test. Another form consists of two cast-iron discs, one keyed to the axle and the other to the motor spindle. The latter disc has a coil wound round it, through which the motor is gradually short-circuited. This brake is liable to cause the wheels to skid, and should not be used in conjunction with a hand-brake. On a good rail, it can be used for taking a car down a gradient of 1 in 11, but it is safer to use a slipper-brake as an auxiliary. Electromagnetic brakes are expensive; the wear and tear is excessive; moreover, if the gradients are steep, the life of the motors may be appreciably shortened, if the electric brake is constantly used, as the motors never get an opportunity of cooling down. Some figures are given showing results obtained with the different forms of brake.

W. H. S.

2041. *Signalling on Outlying Siding Connections.* **A. W. Szlumper.** (Inst. Civil Engin., Proc. 144. pp. 11–15; Discussion, pp. 23–42, June, 1901.)—Between two block-section boxes the lever working the siding-points may be fitted with a lock which can only be operated by a tablet obtained from the tablet-instrument in the section-box, the absence of a tablet from this box effectually blocking the line until it is either returned or taken to the next section-box in advance. Another device is an Annett key in the section-box, the removal of which locks the tablet-instrument and the starting signal: it is then taken by the shunter to the siding, and is used to unlock the lever working the points. While the key is absent no trains can be received or sent on this particular section. For siding-connections with a double line without a cross-over the old system was a ground frame with three levers working points and outdoor signals, home and distant, with no control by the section-boxes. An improved method for a siding-connection without a cross-over road for the Sykes "lock-and-block" system, is a combination of an Annett key and a Sykes block-instrument. For shunting operations at the intermediate siding one of these keys must be taken out. But it cannot be removed until the home and distant signals are at danger, and, further, to release a key in one section-box the signalman at the other box must plunge his instrument. The removal of the key breaks down the block instrument until the key is replaced at one or other section-box. No outdoor signals for the siding are required.

Another satisfactory method is to have a ground frame-box and outdoor signals at the siding. An electrical locking-instrument is fitted in both the section- and the siding-boxes. The shunter first opens a cupboard on the outside of his box where there is a bell, using an ordinary carriage key, and sends a bell warning: the signalman at the section-box with a small lever unlocks the instrument at the siding, removes the lock in the distant signal lever tappet, and unbolts the cabin door. When operations are over this door is again closed, and a handle attached to the locking-rod, which can be got at through the cupboard, is raised, restoring the normal arrangements and plunging and freeing the instrument in the section-box. Everything being locked up in the cabin the apparatus cannot be tampered with. If there is a cross-over a switch is provided at the siding which is turned after the bell-warning is sent. If the section is clear the push in the section-

box is held in, freeing the locking instrument at the siding, raising the lock from the tappet on the distant signal lever and sliding the block switch to the "in" position. The siding-box is now switched in as a section-box, and shunting operations proceed. This plan is used on the L.S.W.R. In the discussion, **A. T. Blackall** suggested additional protection by home and distant signals worked from the ground-frame in the improved scheme for a siding-connection without a cross-over road. **A. W. Szlumper** called attention to the fact that the electric lock-and-block system, combining the block instruments with the outdoor signals is being largely adopted. But in case part of a train should break away, the line is fouled, although the front part works the treadle and clears the line. The mechanism can be fixed to the last car, but in the case of goods trains this cannot be always in place. The alternative seems to be the track-circuit as used in America, which means a continuous treadle. Wheels with wooden centres would not, however, cause the necessary short-circuit. **F. E. Robertson** proposed in such cases to fix a wire from the box of the wheel to the tyre, and **A. H. Johnson** remarked that it would not be necessary to wire all the wheels: the engine has iron wheels: those of the guard's van would have to be wired: a strip of metal could be used. In the United States all signals were being worked automatically. The electro-pneumatic system was seen to great advantage in large yards, such as Boston, St. Louis, Pittsburg, or Philadelphia. There was one installation on the G.E.R. in England, but it did not do the system justice. **W. J. Griffiths** had installed the last named at Whitechapel, but there was no scope there for speed and no fixed time-table, the up-road and down-road being at times subject to shunting from one to the other. Still the system enabled 15 per cent. more trains to be handled than formerly at the busiest hour of the day. **W. S. Boult** proposed to have magnetic indicators and bells on the engines themselves, so that both the driver and fireman can read the signals and no look-out ahead need be kept. He would place magnets at desired positions on the road which would actuate "armature-relays" on the engines as the latter passed these positions. **F. W. Webb** and **W. H. Preece** alluded to the system of electrical points and signals now being introduced at Crewe. One of the main-line junctions had been working with great success. One box for controlling the north end of Crewe Station will have 300 levers. The station would be nearly four miles in length. There will be a central power-station to do all the electric lock-and-block work, lighting, and perhaps some heating. The points are brought over by motors placed underground. There would be additional security, greater speed, and capacity for dealing with more traffic. E. O. W.

2042. *Signalling on the Waterloo and City Railway.* **A. W. Szlumper.** (Inst. Civil Engin., Proc. 144. pp. 1–10; Discussion, pp. 23–42, June, 1901.)—There are two signal-boxes, one at Waterloo and the other at the City, the former containing 16 levers, and the latter 18. Each line is practically divided into two block sections by intermediate signals fixed about half-way between the two stations, and controlled electrically from both boxes. Between the points and signals, ordinary mechanical locking obtains, but between the signals and treadles Sykes electric interlocking exists, the trains controlling the signals. The levers and tappets are of ordinary pattern. If a train is to start from Waterloo for the City, (1) a warning-bell signal is sent to City; (2) at the City, if certain treadles are in normal condition, that is, if no train is operating them, and the lever therefore not electrically locked

No. 16 lever (up-line "stop" or "home" signal) is pulled; (3) the City block-instrument is then plunged; (4) No. 2 lever at Waterloo is thus released; (5) the movement of No. 16 lever at the City has set up a current to the City up distant signal; (6) No. 2 lever being worked at Waterloo the circuit just referred to is completed; (7) at Waterloo the advance starting signal is lowered, setting up a current through a "selector" on the starting signal, and either the "right away," or "shunt by" arms can now be obtained, subject to the conditions of the treadles on the section beyond the advance starting signal; (8) if this signal can be lowered the "right away" can be given; (9) the train starts and No. 3 lever (starting signal) is back-locked until the train has passed a bar outside the platform; (10) the train clears that bar and the lever is restored to its normal condition and becomes electrically locked until the train passes a bar which is beyond the advance signal; (11) this movement releases the lock in No. 2 lever, which enables it to be restored; (12) lever No. 3 can now be worked again for lowering the "shunt by" arm on the starting signal, which permits a a second train to leave Waterloo and to travel as far as the advance starting signal; (13) on arrival of the first train at the City up-platform No. 16 lever is restored. If the signalman at Waterloo requires to put the starting signal back to danger before the train has started, he can do so by working the lever three-quarters back, when the signal goes to danger. This does not affect the electric lock: all signal levers are so arranged. Supposing that a driver should endeavour to pass a signal at danger, a slipper bar cuts off the current from the motor and the train, therefore, is unable to proceed.

E. O. W.

2043. *Signalling on the Liverpool Overhead Railway.* **S. B. Cottrell.** (Inst. Civil Engin., Proc. 144. pp. 16–22; Discussion, pp. 23–42, June, 1901.) —An electrically worked line $6\frac{3}{4}$ miles in length, 2 terminal and 15 intermediate stations, and 2 junctions in connection with the carriage-sheds, workshops, &c. There are mechanical signals at the termini and junctions, and Timmis's automatic system at the intermediate stations. This arrangement was estimated to be the least costly. At the intermediate stations there are the usual semaphore and spectacles, with a fixed Timmis's long pull magnet one-third of the way up the post. This operates the arm, and a dead-weight brings it to danger when the circuit is broken. Under the signal are two "breaking" contacts coupled in series, so that one at least will act, and $1\frac{1}{2}$ train-lengths ahead is the "making" contact, also in duplicate. A train on leaving a station passes the former, and the last coach puts the starting signal to "danger," then passes the latter, which pulls off the home signal of the station it has just left and the starting signal of the station in the rear. When the armature of any signal magnet is pulled down by current from the station in advance, before the circuit is broken another contact is made bringing in the holding-off circuit. This latter is supplied from a battery at the station where the signal is situated; in this circuit which passes through the "breaking" contact a high resistance is inserted which reduces the current from 5 to 0·25 ampere. The magnet with 5 amperes will raise a weight of 56 lbs. at a distance of 2 inches. Accumulators for 50 volts work the signals. The expenditure of electric energy is very small. As the stations are very near together there are only 4 signals at each—2 home, and 2 starting—the latter being practically the distant signal for the station in advance. This protects the train, and if it fails to go to "danger" a simple dead-weight switch will

not come into play, the result being that there will be an absolute block on the section in rear.

Discussion.—**W. J. Griffiths** alluded to an accident on the Paris Metropolitan Railway, where vehicles broke away and ran back. The striker in use on the Liverpool Overhead Railway would not meet this difficulty, and there might be no time to stop a following train. **F. W. Webb** also mentioned a case in Paris where an electric engine failed on an ascent, ran back, and liberated a signal in the rear; the following train then ran into that in advance. He gathered that at Liverpool a train could be set back to a certain extent without danger. **W. H. Preece** said that for an absolute block, the signal must not only be at danger behind a train, but the section behind must be *dead*. No train could then move in that section, as there would be no current. This had not been done at Liverpool because the trains were so near to each other. He thought that it would be advisable on the London Metropolitan. **A. W. Szlumper** said that *dead* sections were practically constituted in the Waterloo and City Railway in the fact that the slipper-bars cut off electricity from the motors if a train approached within a few yards of a signal when it stood at "danger." E. O. W.

ELECTRIC LAMPS AND LIGHTING.

2044. *Photometric Tests of Arc Lamps.* (Elect. World and Engineer, 37. pp. 894–897, May 25, 1901. Paper read before the National Electric Light Association. See also Abstract No. 2347, 1900.)—The report of **C. P. Mathews** is continued. Tests were made on various samples of carbon in 110-volt alternating-current enclosed arc lamps, and the results are given in the form of life curves and tables. The average consumption was about 6 inches with a life of about 100 hours and a luminous intensity of about 220 Hefner units. Series direct-current enclosed arcs were tested, taking 6·8 amperes at 70 volts and giving a mean hemispherical intensity of about 330 h.u. An alternate-current series enclosed arc gave similar results. The tests are being continued. A. H. A.

2045. *Arc Lamps.* **A. Bochet.** (Soc. Int. Élect., Bull. 1. pp. 298–306; Discussion, pp. 306–311, June, 1901.)—This paper deals with low voltage alternate-current enclosed arc lamps from 35 to 38 volts, and those of medium voltage, from 38 to 50 volts. It gives the size of carbons best employed with different currents on the different voltages. Remarks are made on the controlling mechanism of arc-lamps, and the author advises when three lamps are in series on a constant voltage, that one differential lamp shall be used to keep the current constant, the other two lamps being furnished with shunt electromagnets, keeping the difference of potential constant in each arc. In the air dash-pots of lamps it is advisable to insert valves so as to allow the air to enter when the carbons approach, or to allow the piston-rod a certain amount of play in the piston, thus enabling the carbons to come together more rapidly at the commencement of their movement towards each other when the lamp feeds. In alternating lamps it is advisable to employ regulators in which the displacement of the cores in the regulating bobbins is as small as possible, so as to keep the self-inductance of the lamp as constant as possible.

In the discussion, **A. Lecomte** read a note on enclosed arc lamps. E. C. R.

2046. *Continuous-current Electric Arcs.* **P. Janet,** with **F. Laporte** and **C. Léonard.** (Soc. Int. Élect., Bull. 1. pp. 251–296 ; Discussion, pp. 306–311, June, 1901.)—This paper gives the results of experiments carried out at the "Laboratoire Central d'Electricité," on the photometry of the direct-current arc. The photometric measurements were taken by means of a Blondel "lumenmeter." In this instrument the arc is in the centre of an opaque sphere, out of which are cut two sectors having an angle of 18° each ; consequently one-tenth of the total luminous flux escapes by these openings from the sphere, and this falling on a mirror of elliptical section, is reflected and concentrated on a white screen about 3 metres distant. This screen is taken as a luminous source, and illuminates the screen of a photometer placed before it and at a fixed distance from it. This illumination is balanced by moving a glow-lamp of known candle-power on the other side of the photometer screen. The paper is illustrated by curves giving the relations between the total flux in lumens and the volts in the arc for different currents, the total flux and the amperes for different volts, curves of equal luminous fluxes, with volts and amperes as co-ordinates, curve of constant power in watts with volts and lumens per watt as co-ordinates. Also curves of the consumption of the carbons are given. The influence of the diameters of the carbons on the luminous flux is discussed theoretically, and the results of experimental determinations given. Finally, experiments on the luminous flux produced by two or three lamps in series on a 110-volt supply are described. In this case, with the current at 8 amperes, the potential difference per lamp was 33 and 43 volts, the luminous flux per lamp 2,800 and 3,900 lumens, and the total luminous fluxes 8,400 and 7,800 for three and two lamps in series respectively. E. C. R.

REFERENCES.

2047. *Storage Battery Boosters.* **L. Lyndon.** (Elect. World and Engineer, 37. pp. 972–974, June 8 ; 1015–1017, June 15 ; 1071–1073, June 22 : 1112-1113, June 29 ; 38. pp. 13–14, July 6 ; and 64–65, July 13, 1901.)—These articles give an account of the various methods of employing storage batteries in lighting and traction systems for the purpose of smoothing out the current fluctuations and equalising the load on the generators. They are classified into "floating batteries"—*i.e.*, simple parallel connection across the mains—shunt, series, compound, differential and constant current boosters. In each case the most suitable conditions for the application of the method are indicated ; algebraical formulæ are worked out for determining the size of the booster dynamo, best number of cells and so forth ; and diagrams of the connections are given. E. J. W.

2048. *Storage Batteries in Power Stations.* **L. Lyndon.** (Street Rly. Journ. 18. pp. 18–22, July, 1901.)—This article deals with the use of accumulators as—(1) a reserve to store energy during light load and discharge on the "peaks" ; (2) a regulator to absorb or compensate for rapid fluctuations of current demand ; (3) a regulator on a long feeder-supplying receiving apparatus so as to maintain at all times a uniform voltage at the terminals of the receiver. Curves and data are given to assist in determining the best size of battery, taking into account its cost (including boosting machinery) as against that of the generating plant which would otherwise be required. The method of arriving at the comparative operating costs is considered : also the most suitable types of booster machines to be used. E. J. W.

2049 *Electric Underground Railways.* **J. Lowy.** (Zeitschr. Elektrotechn. Wien, 19 pp. 284–288 ; Discussion, p. 288, June 9, 1901. Paper read before the Elektrotechn. Verein, Wien, Jan. 30, 1901.)—It deals generally with the problems presented by the working of underground railways electrically, and gives statistics, of the fourteen underground railways which are at present in use. E. K. S.

2050. *Financial Aspects of Electrical Supply.* **W. A. Chamen.** (Electrician, 47. pp. 327–329, June 21, 1901.)—Presidential address to the Incorporated Municipal Electrical Association.

2051. *Electrical Installation in Paper-works.* **A. D. Adams.** (Elect. World and Engineer, 37. pp. 1101–1103, June 29, 1901.)—A description of a water-power installation at Millinocket, Maine.

2052. *High-Tension Traction.* **F. Koromzay.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 138–163, July 6, 1901.)—This article contains a statement of the arguments advanced in favour of the so-called Ganz system of supplying high-tension polyphase current to motors carried on the train. The matter herein contained is very similar to that of the paper which has been already noticed in Abstract No. 464 (1901). W. H. S.

2053. *Electric Railways.* **M. Schiemann.** (Elektrotechn. Zeitschr. 22. pp. 595–598. July 25, 1901. Paper read before a meeting of the Verband Deutscher Elektrotechniker at Dresden.)—The author gives a general outline of some Continental schemes which are either under consideration or construction. He also deals generally with the various methods by which high-tension current can be applied to such schemes. W. H. S.

2054. *Cost of Power for Tramways.* **W. H. Tittensor.** (Electrician, 47. pp. 488–489, July 19, 1901. Paper read before the Municipal Electrical Association at Glasgow.)—A discussion of the question as to the price to be charged for energy supplied to tramways from a station providing power both for lighting and traction. W. H S.

2055. *Overhead Low-Tension Distributing Systems.* **Bönninghofen.** (Elektrotechn. Zeitschr. 22. pp. 635–637, Aug. 8, 1901. Paper read before the Verband Deutscher Elektrotechn. at Dresden.)—The author gives an illustrated description of the poles, brackets, couplings, &c., used by the Allgemeine Elektricitätsgesellschaft, suitable for either copper or aluminium overhead distributing systems working at a pressure below 1,000 volts. A. H.

2056. *Motors for Electric Automobiles.* **P. Gasnier.** (Ind. Élect. 10. pp. 342–347, Aug. 10, 1901.)—This article contains particulars of a considerable number of motors of various sizes and types, manufactured by the Postel-Vinay Company, and including, in some instances, details of the running gear with which they have been employed. Figures and curves are given relating to their outputs, weights, speeds, efficiencies, &c., and some illustrations of their mechanical design. E. J. W.

2057. *Farnworth Electricity Works.* (Elect. Engin. 28. pp. 258–266, Aug. 23, 1901.) —A description with drawings of the lighting and tramway system in this town. Three Lancashire boilers, 30 ft. by 7 ft. 6 in., and three 120-kw. continuous-current generators have been installed. There is also a battery, giving 20 kw. for 10 hours. W. H. S.

2058. *Electricity Works in Germany.* (Elektrotechn. Zeitschr. 22. pp. 720–742, Sept. 5, 1901.)—A list in tabular form of the various electric light stations in Germany, giving particulars about each. [See also Abstract No. 2357 (1900).]

TELEGRAPHY AND TELEPHONY.

2059. *Rowland's Multiplex Printing Telegraph.* **G. Robichon.** (Journ. Télégraph. 25. pp. 6-9, Jan.; 25-28, Feb.; 73-76, April; and pp. 175-179, June, 1901.)—This was briefly alluded to in Abstract No. 1309 (1899). Four messages can be sent each way. Alternate currents are employed and the generator and motor at either end of the line are in synchronism. The signals are made up by suppressing at the station of origin one or more half wave-lengths of current which cause the armatures of selective relays to close local contacts for certain periods of time, and thus actuate the printing type letters. These armatures are oscillating until the sudden suppression of current leaves them on one contact or the other. The period of a complete wave intervenes between these suppressions; otherwise the contact would be of the same sense in both cases, which is not desired. The sector or distributor has eleven studs, and a revolving arm, geared to the transmitting alternator, comes successively into contact with these studs. Such a contact, through the medium of the keyboard and a local electromagnet, momentarily cuts off the line, and suppresses a half-period. Contact with all the studs, one after the other, were the local circuit complete, would mean the suppression of eleven half-periods. But the arrangement of the keyboard is such that, for each letter depressed, two half-periods, non-successive, are cut off. The transmitter is lettered and the keys arranged similarly to a typewriter. When a key is pressed it raises two levers which come into circuit with two separate studs of the distributor, a local battery, an electromagnet, and the contact arm above mentioned, which revolves round the distributor. When this local circuit is complete the armature of the electromagnet moves and interrupts the line, thus cutting off a half-period of current. Were the time of contact or manipulation of the key to be solely at the judgment of the operator, the performance would be liable to irregularity. Hence there is an arrangement, worked electromagnetically, by which one key only can function during any one revolution of the arm of the distributor, the end of the lever of such key being kept hooked up, and in continuous contact with the sector during the whole of that one revolution. The operator is made sensible by touch of the working contact having been properly made. A counter, worked by a click, indicates to the sending operator when the time has come to alter the position of the paper hand under the type-wheel, and to use the appropriate key: to this is added a bell which rings when the end of a line is near.

Synchronism is effected by the second oscillating armature of the line relay as follows. Its tongue plays between the + and — poles of a battery. These poles are connected also to two condensers respectively; these condensers being in parallel, their middle point is joined to auxiliary bobbins of a small motor which is separately driven, and causes the arm of the distributor to turn round; the other terminal of the bobbins is joined through a telephone to the body of the oscillating tongue. The small motor thus receives + and — pulsations as long as the tongue moves in sympathy with the alternations of the line current, and the suppression of half-waves does not disturb its movement. This arrangement has for its object to cause a certain note to be emitted by the telephone which shall indicate that synchronism is being

maintained, and also to exercise a very slight acceleration or retardation upon the working armature in case of deviation from synchronism. When such takes place, the current working the motor can, by means of a rheostat, be adjusted and synchronism restored.

When, however, a line circuit is introduced, absolute identity of movement is unfavourable. There is a slight retardation in transmission which must be taken account of. One distributor must be "oriented" with regard to the other. This is effected by a special relay and by the peculiar mounting of the arm of the receiving distributor. The axis of that arm is commanded by the synchronising motor, but the arm is not rigidly secured to the axis; it turns with it by slight friction. Alongside of the arm and rigidly fixed to the axis is a disc of metal which has a certain number of indentations equidistant, the space separating two consecutive ones being equal to two divisions of the crown of the distributor. The arm carries an electromagnet whose armature prolonged forms a click or little tongue which in repose engages in one of the holes or indentations of the metal disc and serves to unite the arm with the disc, and normally the two revolve together. The electromagnet is in the local circuit of the relay of "orientation," which is itself connected to one of the contacts of the distributor. At the transmitting station a wave of current is suppressed when the arm rubs on a similar contact. If, at the receiving end, the arm is simultaneously passing over the relay contact, matters are so arranged that the relay does not function, the little tongue or click remains locked with the disc, and the regular movement of the arm and disc is uninterrupted. Otherwise, however, the local circuit is momentarily closed, the little tongue or click is drawn back, the arm falls behind the disc by the space of two divisions, and the tongue again locks. In the succeeding and following revolutions, if the correct relation has not been established, the same thing occurs until the object is effected. To indicate to the sending stations that concordance has been secured there exists a second contact on the distributors through which a second wave is automatically suppressed at each revolution. A special relay acts at the sending station by means of these contacts to ring a bell when the relation between the movements of the arms at the sending and receiving ends are in proper relation.

E. O. W.

2060. *Duplexing of Cables.* **H. H. Kingsford.** (Inst. Elect. Engin., Journ. 30. pp. 1020–1021, June, 1901.)—By placing a resistance earthed at about its middle point between the commencement of the cable and that of the artificial line, the latter can be much reduced both in capacity and resistance, without making any perceptible difference to the duplex balance, the signals at the distant end being as easy to read as they were before the earthed shunt was applied. The author first employed this method to obviate the embarrassment arising from a fall in insulation of underground cable between hut and office. In one case quoted, a leak resistance, equal to that of the fault, is also applied at the beginning of the artificial line. E. O. W.

2061. *Type-printing Telegraphy.* **W. B. Vansize.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 349–362, May, 1901.) (Discussion.)—This is the report of the discussion on the paper referred to in Abstract No. 1013 (1901). Further details of the construction of the apparatus are given, and incidentally some useful particulars are stated by **F. W. Jones** and others when comparing the speeds to be attained by various systems of sending and receiving. The best that Morse operators of the greatest skill can do in a

day's all-round work is 30 words per minute, using a sounder and an ordinary type-writing machine. In forming an estimate of the merits of any automatic system, attention must be directed to the expenditure of time at the start, and at the finish of a message, as well as to the expense of preparing tapes and translating them. The Wheatstone system was introduced into the United States in 1880; there were then seven circuits installed, but to-day there are only five. The rate of pay of operators and the number of messages they can transmit per day is also discussed. It is stated that for several years past the average length of a message (Boston–New York) is from 29 to 30 words. Each operator sends from 60 to 65 messages per day.

R. A.

2062. *Speed of Signalling by Simple Sine-wave Transmission.* **F. Breisig.** (Elektrotechn. Zeitschr. 22. pp. 415–419, May 16, 1901. Communicated by the Kaiserl. Telegraphen-Versuchsamt.)—This is a critical examination of the method adopted by Crehore and Squier for the transmission of signals through cables using current impulses of simple sine form. The question at issue is whether the signals transmitted by the alternate-current generator for practical cable work, consisting as they do of periodic half-waves, following one another in an irregular sequence of positive and negative impulses, can be regarded as mathematically equivalent to an alternate current of sine form. There follows the further question as to whether such signals can be transmitted at a speed greater than is possible with ordinary battery currents. To investigate the matter, the author considers the case of transmission of periodic impulses in which the time interval between any two successive contacts at the sending end is great enough to allow each impulse completely to vanish before it is followed by another. As minimum legibility is obtained with such recorder signals as are formed of a series of successive impulses all of the same polarity, the investigation is limited to a series all of one sign. Assuming that legibility is to be judged by comparison of amplitudes at equivalent potential differences, the author criticises the conclusions of Crehore and Squier. In their experiments comparing the speeds obtained respectively by battery currents and alternate currents, Crehore and Squier defined equivalent voltages as those having the same maximum values at the sending end of the cable. For alternate-current sending, the volts were directly measured; and the amplitudes were calculated by multiplying the effective volts by $\sqrt{2}$. The equivalent voltage in the case of a battery current was assumed to be simply the e.m.f. of the battery. This assumption is severely criticised by Breisig. He regards it as leading to false conclusions, and he expresses the opinion that sine-wave alternators have no advantage over batteries as regards speed of signalling through cables. [See further Abstracts Nos. 1014 (1901) and 1969 (1900).]

R. A.

2063. *The Electrograph.* (Scientific American, 84. pp. 373–374, June 15, 1901.)—In this instrument the transmitter has a rotary cylinder round which is curled a zinc enlargement of a half-tone plate, the depressed portions corresponding with the etched portions of the original half-tone being filled with an insulating material. Upon the surface of this plate glides a stylus, which is caused to travel along the rotating cylinder by a carriage. Upon a piece of ordinary paper wrapped upon the cylinder of the receiving instrument plays an inked pen, which is caused to travel along the rotating receiver-cylinder, the inked pen being withdrawn from the paper when the stylus at the transmitting end is in contact with insulating material. The apparatus

has worked over a line 770 miles long, and through 20,000 ohms of line resistance, and is the invention of H. R. Palmer, T. Mills, and W. P. Dun Lany. The paper is illustrated by some photographs. Further details are given in British patents Nos. 6159 and 6160 of 1899. C. K. F.

2064. *Wireless Telegraphy.* **F. Poncelet.** (Soc. Belge Élect., Bull. 18. pp. 200–221, May, 1901 ; also Elect. Engin. 28. July 12 and 19, 1901.)—A description of some experiments carried out by Guarini and the author between Brussels, Malines, and Antwerp, with Guarini's automatic repeater. The distances between successive stations are only about one-third of those obtained by Marconi. The paper also contains statements as to a method of obtaining a beam of electrical radiation from a vertical wire, but does not give any experimental results in confirmation. J. E.-M.

REFERENCES.

2065. *Dynamo in Recent Telephone Practice.* **D. M. Bliss.** (Elect. World and Engineer, 37. pp. 308–310, Feb. 23, 1901.)—The author describes types of dynamo and storage cells (their arrangement and care) best suited to central battery telephone systems. Illustration and diagrams are given. J. E. K.

2066. *Modern Telephone Engineering.* **K. B. Miller.** (Elect. World and Engineer, 37. pp. 712–714, May 4, and 765–768, May 11, 1901.)—A full description of the most modern arrangements in exchanges with central batteries and lamp signals in place of electromagnetic indicators, with diagrammatic illustrations of the connections and the modes of putting up strips of relays, lamps, and jacks. There are also diagrams of load curves showing the business of an exchange at different times and days. E. O. W.

2067. *Wireless Telegraphy.* **G. Marconi.** (Soc. Arts, Journ. 49. pp. 506–515 ; Discussion, pp. 516–517, May 17, 1901.)—This is an account of the author's experiments in the direction of obtaining syntonism in wireless telegraphy. A short review of the subject is given, and references to various patents concerning the form and disposition of apparatus. Examples of the practicability of syntonic wireless telegraphy are cited, and the suggestions of Slaby and others are criticised. [Syntony was discussed by O. Lodge, January 21, 1898, at the Physical Society, see Proceed. Phys. Soc. Lond., vol. xvi. pp. 58–61, 1898.] R. A.

2068. *Transmitters for Wireless Telegraphy.* **F. Braun.** (Elektrotechn. Zeitschr. 22. pp. 469–470, June 6, 1901.)—In continuation of his paper [Abstract No. 1464 (1901)] on modifications in the Marconi system of wireless telegraphy, the author describes a number of methods of inductive and other excitations of the transmitter. The connections include the use of inductive coils and condensers in connection with spark-gaps. G. H. B.

2069. *Wireless Telegraphy.* **R. A. Fessenden.** (Elect. World and Engineer, 37. pp. 1103–1104, June 29, 1901.)—The American Weather Bureau has instituted experiments on syntonic wireless telegraphy, somewhat on the same lines as those of Marconi. They are here referred to in general terms, but awaiting the granting of patents, no details are given. R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

NOVEMBER 1901.

GENERAL PHYSICS.

2070. *Surface Tension of Liquid Air.* **L. Grunmach.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 38. pp. 914–918, July 25, 1901.)—The measurements were made by means of the method of capillary ripples. The density of the liquid was determined by a Mohr balance, and its composition ascertained by removing some in a small spoon and rapidly plunging it under a bell-jar filled with water. The gas so obtained was analysed by absorbing the oxygen by means of copper in an ammonia-ammonium carbonate solution. Temperature was measured with a petroleum ether thermometer of 59^{III} Jena glass (made by C. Richter, Berlin). Results :—

Oxygen Percentage.	Surface-tension (dyn/cm).	Temperature.
49·9	11·61	— 190·3° C.
63·9	11·89	,,
65·3	12·05	,,
66·8	11·90	,,
67·6	11·91	,,
74·4	12·23	,,
76·45	12·51	,,
76·7	12·63	,,

F. G. D.

2071. *Limnimeter.* **H. Ebert.** (Zeitschr. Instrumentenk. 21. pp. 193–201, July, 1901.)—This instrument records the amplitude and frequency of waves on lake surfaces. It consists of a cylindrical float or piston, working in a vertical cylinder which can be lowered into the water. The outer cylinder is intended for excluding from the records the fortuitous waves due to wind or to direct mechanical disturbances. The vertical movements of the piston are transmitted by means of a Hooke's joint to a stylus giving a trace on a recording drum. The apparatus is fully described, and examples of the sinuous records from Geneva are given, showing among other things the interference curves for various sets of pulsations. R. A.

2072. *Nineteenth Century Clouds over the Dynamical Theory of Heat and Light.* **Kelvin.** (Phil. Mag. 2. pp. 1–40, July, 1901. Lecture delivered at the Royal Institution of Great Britain, April 27, 1900.)—Cloud I. concerns the

relative motion of ether and ponderable bodies. Fresnel's and Young's hypotheses being inconsistent with the elastic-solid theory of ether, the relinquishment of the doctrine that two portions of matter cannot jointly occupy the same space is suggested ; ponderable bodies may then be assumed not to displace ether as they move, while each atom alters the density-distribution of the ether within the space which it occupies itself. This hypothesis will explain (1) how matter can act on ether so as to produce light, (2) why the speed of light is less in transparent ponderable matter than in pure ether, (3) the aberration of light ; but it is inconsistent with Michelson and Morley's experimental conclusion that ether in the earth's atmosphere is motionless relatively to the earth, unless indeed the motion of ether through matter alters its linear dimensions. This cloud must be regarded as still very dense.

Cloud II. relates to the Boltzmann-Maxwell doctrine of the equal partition of the average kinetic energy of a system among all its degrees of freedom. After a short history of its formulation, the relation $k - 1 = 2/3i\,(1 + \mathrm{P})$ deduced from it is discussed for some simple cases, and the results are held to absolutely disprove the doctrine. To confirm this disproof elaborate calculations for several test cases have been carried out, some directly and others by the aid of a lottery, and it is found that (1) when a particle moves on a triangular billiard table with angles of 97°, 53½°, and 29½°, and undergoes, 599 reflexions, the ratios of the average components of kinetic energy in different directions to the actual kinetic energy are not uniformly 0·5, according to the doctrine, but vary between 0·5363 and 0·4637 ; (2) when the table has a circular boundary of infinitely small semicircular corrugations, the average radial and average transversal components of the kinetic energy for 142 reflexions are not equal, as the doctrine requires, but in the ratio 346 : 279 ; (3) when a rotator, formed of equal masses rigidly connected by a massless rod of negligible length, is reflected backwards and forwards between two parallel planes, the average rotatory and translatory kinetic energies for 109 reflexions are in the ratio 95 : 62, instead of being equal. Similar results are also obtained on considering the motion of a heavy particle which bounces on a horizontal floor with semicircular cylindrical hollows of infinitely small radius, and that of a heavy rotator as above bouncing on a plane floor, and the motions of the same bodies when not heavy but attracted to the floors by a force varying as the distance ; also in other cases.

It is incidentally suggested that the atoms of so-called monatomic gases may have satellites—query, J. J. Thomson's ions—of exceedingly small mass in comparison with their own ; this would account for the complexity of their spectra and also for the slight differences from $\frac{5}{3}$—invariably in defect—of the ratios of their specific heats. R. E. B.

2073. *Ether and Gravitational Matter in Space.* **Kelvin.** (Phil. Mag. 2. pp. 161–177, August, 1901.)—The author refers to his Baltimore Lectures, 1884, of which this paper is an amplification, and which he hopes shortly to republish. Then follows a note on the possible density of the ether, and on the mechanical value of a given volume of sunlight. This mechanical value can be calculated in heat units from Pouillet's researches. That being known, the mechanical energy in the given volume is known, and if we know the mass of the contained ether we can thence determine its velocity of vibration as the sunlight passes through it, or if we know the velocity we can determine the mass. The result obtained is that the mass in grammes of a cubic kilometre of ether near the sun is $20{\cdot}64 \times 10^{-7} \times n^2$, where n is the ratio of

the maximum velocity of vibration to the velocity of light. This ratio cannot be calculated with certainty, but it seems improbable that it can be greater than $\frac{1}{50}$. The author adds in a note under date November, 1899, that we have strong reason for believing the density of ether to be constant throughout space, whence this constant density, that of water being unity, should be not less than 5×10^{-18}. These considerations lead us, he says, to the conclusion that ether and matter are not mutually exclusive, but may freely occupy the same space, or interpenetrate each other. He then calculates how much compressing force is exerted on the ether by the sun's attraction, and he arrives at the conclusion that the mean density of ponderable matter throughout any very large spherical volume in space is less the greater the radius.

(In these calculations it is assumed that the attraction between masses at all distances, however much greater than interplanetary distances, follows the Newtonian law.)

The author considers, for instance, a sphere where radius is $a = 3{\cdot}09 \times 10^{16}$ kilometres, that being the distance of a star whose parallax is 0·001 of a second, and proposes the question whether there can be as much matter as 10^9 times the sun's mass within such a sphere. If there were, the mean normal force of attraction over the surface of that sphere would be $1{\cdot}37 \times 10^{-11}$ times that of gravity at the earth's surface. It is possible thence to calculate the mean velocity which a body outside of the "a" sphere would acquire under the influence of that attraction in a given time. In one year it, for instance, would be $4{\cdot}32 \times 10^{-6}$ kilometres per second. The author concludes that given such a number of masses, initially at rest 25 millions of years ago, or so situated then that they are now distributed through the "a" sphere with approximate uniformity, they would now have, on an average, some such velocities of motion through space as we have reason to believe the visible stars do in fact possess.

Kelvin also calculates from the ratio of starlight to sunlight the density of stellar distribution, assuming every star to be equally luminous with the sun. He tests by this means the old hypothesis that if we could see far enough we should see a star in every possible direction, and the only reason why we do not is that light suffers absorption in passing through space. In order that this hypothesis might be true, the outlying stars must be so distant that the time of passage of light from them to the earth would be $3\frac{1}{4}$ million times the life of a star, calculated in case of the sun to be about 50–100 millions of years. S. H. B.

2074. *Interpretation of Seismic Records.* **A. Cancani.** (Accad. Lincei, Atti, 9. pp. 94–96, 1900.)—The author contests Viola's assertion [see Abstract No. 1987 (1900)], that a vertical pendulum can show neither the direction nor the duration of a seismic disturbance, but only the moment at which it occurs, and that the subsequent movements are due to vertical oscillations. He adduces evidence showing that oscillations of the same period as those registered by the seismograph have been observed by other means, and that in certain cases, where the disturbance lasted several minutes, it was impossible to attribute the registrations merely to the initial shock. G. H. B.

2075. *Effect of Wind on Seismic Instruments.* **G. Agamennone.** (Accad. Lincei, Atti, 9. pp. 308–313, 1900.)—Delicate pendulums, or seismometers, show very frequently spontaneous oscillations which are attributed by many observers to causes other than seismic. To determine their cause, the author made observations on an instrument in the Rocca di Papa

observatory; it was attached to a central pillar in the observatory, built on the rock, and entirely separated from the building, and would therefore appear to be well protected from any but seismic influences. Nevertheless the author concludes that its oscillations are attributable in many cases to the effect of wind, and gives details of the observations which led him to this conclusion. G. H. B.

2076. *Thunderstorms.* **A. F. Sims.** (Elect. Rev. N.Y. 39. pp. 132–133, Aug. 3, 1901. From a pamphlet published by the General Electric Company.)—*Remarks on Thunderstorms and their Forecasting in the United States.* The thunderstorms generally develope in the south-east quadrant of a low pressure area, 400 or 500 miles from its centre, and travel towards the east or south-east, at less speed than the low barometer area, the region favourable for their development spreading out in a fan-like manner. Thunderstorms occurring in the south-west quadrant of a low barometer area are generally sporadic in character; small storms only are affected by the topography of the country. H. B.

2077. *Scintillation of Stars.* **K. Exner.** (Akad. Wiss. Wien, Sitz. Ber. 110, IIa. pp. 73–123, Jan.–March, 1901.)—The first twelve pages are occupied by a historical sketch of the various theories from the time of Aristotle, the last twenty by a discussion of recent literature on the subject, and the remainder by a discursive account of the author's views and experiments. Various forms of scintillometers are described. The phenomena are attributed to irregular refraction in the earth's atmosphere, due to successive warmer and cooler air currents, or to this cause combined with regular atmospheric dispersion. The effects were imitated in the laboratory by the aid of a piece of window-glass and a prism, the action of the wind being represented by moving the glass. The author's observations lead him to the result that the wave fronts from the fixed stars, originally plane, acquire, in passing through the atmosphere, irregular convexities and concavities continually changing with the motion of the air. The depth of such a convexity is of the same order of magnitude as a light wave, the breadth is of the order of a decimetre, and the minimum value of the radius of curvature may be about 4,000 m. A. E.

REFERENCES.

2078. *Cellular Whirlpools in a Liquid Layer.* **H. Bénard.** (Journ. de Physique, 10. pp. 254–266, April, 1901.)—Descriptions of various optical devices for studying and recording these [see Abstracts Nos. 1815 (1900), and 86 (1901)]. Measurements obtained are given. A full paper on the subject, by the same author, will be found in the Annals de Chim. et de Physique, 23. pp. 62–144, May, 1901. In this paper the author suggests certain biological analogies. A. D.

2079. *Internal Friction of Gases.* **P. Breitenbach.** (Ann. d. Physik, 5. 1 pp. 166–169, May 4, 1901.)—A discussion of Sutherland's theory (Phil. Maga., 1893) which is apparently confirmed by experimental results. A. D.

2080. *Flow of Liquids in Thin Films.* **H. S. Hele-Shaw.** (Comptes Rendus 132. pp. 1306–1312, June 3, 1901.)—A brief account of the author's stream-line method of studying the flow of viscous liquids in thin films, with its application to the solution of electrical and magnetic problems in two-dimensional space. A. H.

LIGHT.

2081. *Apparatus for Driving the Photographic Plate in using a Siderostat.* **G. Lippmann.** (Journ. de Physique, 10. pp. 415–417, July, 1901.)—As is well known, the siderostat brings only one point of the heavens to rest, the remainder of the field rotating around this point with varying velocity, and several methods have recently been proposed for imparting a similar rotation to the plate receiving the image. [See Abstract No. 1477 (1901).] The author shows that the device used for driving the mirror of the siderostat may also be employed for driving the plate, and remarks that the adjustments involved are comparatively simple. A. E.

2082. *Line Image by Cylindrical Mirror as Meridian Mark in Telescope.* **G. Lippmann.** (Journ. de Physique, 10. pp. 413–415, July, 1901.)—This paper describes an apparatus for use in measuring right ascension, and whose object is to render the meridian visible in the telescope field in the form of a bright line. It consists of two parts, both of which remain fixed during the observations: (1) A collimator, with hole or slit, mounted on pillars with its axis in the plane of the meridian. (2) A hemi-cylindrical mirror a few centimetres in diameter, with its axis horizontal and at right angles to the meridian, placed so as to receive the rays from the collimator. The reflected rays extend from 0° to 360° in planes parallel to the meridian. Owing to this fact the apparatus, though remaining fixed, remains applicable for all declinations. These rays, falling on the telescope objective, form an image at its focal plane consisting of a very fine bright line. This line marks the place of the meridian in the field. It is not necessary to carefully adjust the position of the telescope, which merely plays the part of an ocular. All parts whose adjustment is of importance remain at rest during the observations—an advantage as regards stability. The method is applicable to photography. A. E.

2083. *Influence of Mechanical Stress on Refractive Index.* **F. Pockels.** (Phys. Zeitschr. 2. pp. 693–695, Aug. 31, 1901.)—It has been shown that the refractive index of flint glass increases with the temperature. In order to get the temperature effect cleared from the influence of change in density, Pulfrich used the Gladstone-Dale, or the Lorentz, formula, connecting density with refractive index, although they have not been shown to hold for solids, and in fact give widely different results if the index is high. The author therefore investigates the influence of mechanically produced density changes on the refraction. Light is transmitted through a plate 5 mm. thick, the retardation along the axis of pressure being measured by a Jamin interferometer, and the relative retardations of the two perpendicularly polarised rays by a Babinet compensator; a known stress is then applied to the plate by means of a lever. It is then found that the component polarised perpendicular to the direction of the pressure is retarded relatively to that parallel to the pressure, and, contrary to the usual result, the glass becomes positively double refracting. Finally, the change in the refractive index with density, the pressure remaining constant, being found experimentally, it is seen that the Gladstone-Dale formula gives the nearest approximation, the Lorentz formula being altogether inapplicable. R. S. W.

2084. *Phase-change at Incidence near Critical Angle.* **J. M. de Lépinay.** (Comptes Rendus, 133. pp. 150–152, July 15, 1901.)—In utilising Herschel's fringes for measurement of refractive indices based on observations of the angle of total reflection, the author found that the positions of the first few fringes differed systematically from those assigned to them by theory. The observed facts can only be explained on the assumption that, for angles of incidence nearly equal to (but less than) the angle of total reflection, a retardation of phase is introduced by reflection at the first bounding surface of the thin layer, and also an advance of phase by reflection at the second surface. A. E.

2085. *Constitution of White Light.* **O. M. Corbino.** (Comptes Rendus, 133. pp. 412–414, Aug. 26, 1901.)—Two opposite views of the constitution of white light are stated, and a theoretical decision between them, based on known experimental results, is arrived at. Gouy maintains that the constituents of the spectrum of white light are the sinusoidal components of a single complex vibration, and are capable of mutual interference; while Carvallo regards the separate radiations as completely independent, and therefore incapable of interference with one another. The latter view is supported by the spectroscopic observation of beats produced by two pencils of white light, one of which is slightly altered in period by means described elsewhere by the author and by Righi. In the case of monochromatic light, alternations of light and darkness are observed; in the case of white light, movable fringes are seen. In the latter case the fringe system should exhibit no alteration when the change of period is effected, if the hypothesis of Gouy is true. The fringes are, however, seen to move, and hence it follows that interference takes place only between radiations which had the same period in the source before the alteration of period, and not between those which, originally different, have been brought into coincidence of period. Hence the second hypothesis is accepted. J. W. P.

2086. *Interference Fringes by Circular Double Refraction.* **Damien.** (Soc. Franç. Phys., Bull. 169. p. 4, 1901.)—An account of apparatus and experiments analogous to those described in Abstract No. 1873 (1901), but due to circular double refraction instead of rectilinear. In these second experiments the quartz vessels of Biot are replaced by quartz vessels whose plane face, instead of being parallel to the axis, is perpendicular to the axis of the quartz. The *fringes of subtraction*, analogous to the fringes of the prisms of Sénarmont, are produced by projecting the image of two such vessels formed of quartzes of contrary signs superposed with their centres distinct, and placed between two crossed Nicols. Similarly the *rings of addition* are obtained by using vessels formed of quartzes of the same sign; only, on account of the feebleness of circular double refraction, compared with rectilinear, the vessels must in this case be very deep. J. J. S.

2087. *Visibility and Singularities of Interference Fringes.* **Raveau.** (Soc. Franç. Phys, Bull. 165. p. 11, 1901).—If SA . . . A′S′ and SB . . . B′S′ are the two paths of a light ray between two points, S and S′ on opposite sides of an interference apparatus, then when S is the luminous point, the common normal S′F to A′S′ and B′S′ is a tangent to the intersection of the pair of corresponding wave surfaces, and gives the direction of the fringes observed around S on a screen containing this normal. If S′ is the source, then S′F is the direction of the slit required to give sharp fringes at S.

The author has considered the special case in which A′S′ and B′S′ coincide, so that S′F becomes indeterminate, and finds that with a luminous point at S the fringes at S′ will no longer be approximately rectilinear, but will be determined by equations of the form $ax^2 + bxy + cy^2 = k\lambda$, from which he deduces a geometrical theory of Jamin's interference apparatus, together with some characteristic properties of the fringes obtained with crystalline laminæ. Taking S′ as the luminous point leads to the theorem—If two rays, derived by the aid of an interference apparatus from a single source, intersect again, sharp fringes will be obtained at the intersection point without the use of a slit at the source. G. W. de T.

2088. *Velocity of Light in Magnetic Crystals.* **G. Scalfaro.** (Accad. Lincei, Atti, 10. pp. 109–118, Feb. 17, 1901.)—In the electromagnetic theory of light, to harmonise with Fresnel's laws, the constants of magnetic permeability must be equal in all directions. The propagation of light in magnetic crystals was studied by A. Sella, Rend. Acc. Lincei, 1895, II semestre, p. 237. The author finds that in magnetic crystals, both monoclinic and dimetric, the velocity of propagation of light follows Fresnel's laws within the limits of observational error (which affect only the fifth place of decimals in the values of the radius-vector of sections of the surface of normal velocity), and not the electromagnetic theory. A. D.

2089. *Law of Rationality of Indices in Crystals.* **C. Viola.** (Accad. Lincei, Atti, 9. pp. 301–308, 1900.)—The author considers that Haüy's law of rationality of indices has no value in crystallography, since it is not a law that can be proved experimentally, either from a consideration of the angular measurements or of the symmetry; for from the law of rationality it is possible to deduce a symmetry which is not possessed by the crystal, and symmetry actually found in a crystal does not follow from this law. The two fundamental notions on which crystallography should be based are (1) the physical homogeneity of the crystal, and (2) the fact that there are only 32 different kinds of symmetry possible, the axes of symmetry being binary, tertiary, quaternary, and sexary. T. H. P.

2090. *Indices of Refraction of Mixtures of Liquids.* **J. de Kowalski** and **J. de Modzelewski.** (Comptes Rendus, 133. pp. 33–35, July 1, 1901.)—The indices of refraction in mixtures of liquids do not present the anomalies which the dielectric constants do. It appears that anomalies only occur in the infra-red, through the absorption changing in that region in an irregular manner. A. D.

2091. *Dependence of Radiation-Absorption of a Gas on its Density.* **K. Ångström.** (Ann. d. Physik, 6. 1. pp. 163–173, Aug., 1901.)—The author describes experiments by which he shows that the amount of radiation absorbed by a gas, particularly carbonic acid, depends upon the density of the gas, in opposition to the view that it remains constant provided that pl is constant, p being the pressure and l the thickness of the gas layer penetrated. The absorption is shown to increase with the density, owing to a broadening of the absorption band. Two methods of experimenting were followed with consistent results; in one, two tubes were so connected together that, after the absorption of the gas contained in one had been measured, the gas could be allowed to expand into the other, which had been exhausted; thus the absorption of the same quantity of gas under the same conditions, except as

regards pressure, could be determined. The author considers that thus the results of Arrhenius [see Abstract No. 1907 (1901)] are harmonised with his own, and that his previous conclusions as to the absorption of atmospheric carbonic acid gas are confirmed. W. E. T.

2092. *Photographic Plates Sensitive to Ultra-violet Light.* **V. Schumann.** (Ann. d. Physik, 5. 2. pp. 349–374, 1901.)—The sensitiveness of gelatine dry-plates diminishes rapidly for wave-lengths below 220 $\mu\mu$, on account of the opacity of gelatine for such waves. The author prepared plates sensitive to wave-lengths beyond 185 $\mu\mu$ in 1893 (Sitzungsber. d. k. Akad. d.Wisseusch. zu Wien, 102, p. 415), and the present paper describes an improved method of preparation, giving far better results. A gelatine emulsion very rich in silver bromide is prepared, and allowed to set; it is then cut into small pieces, washed, and dissolved in a large quantity of water, and, after filtration through slag wool, poured on to glass plates. The silver bromide settles, and, after half an hour, the emulsion is poured off, leaving a thin layer of silver bromide. The plates can be used as soon as dry, but gain largely if kept for one or two months; if kept for a longer time, they become fogged. If the emulsion, before filtering, is freed from the larger bromide particles by levigation, the plates are less liable to show spots. The film is extraordinarily sensitive to pressure, even brushing with a camel's-hair brush producing streaks on development. The author recommends a pyro-soda developer.

To white light the plates are far less sensitive than ordinary gelatine plates, and are more sensitive only beyond 230 $\mu\mu$. This is of great advantage in spectral photography, as the diffused light from the prisms and lenses has comparatively little effect. Beyond 182 $\mu\mu$ the gelatine plate gives no image at all, while the author's plates increase in sensitiveness as the wave-length diminishes. The paper contains very full details for preparing the plates.

G. H. B.

2093. *Blue-printing by Electric Light.* **H. G. Reist.** (West. Electn. 28. p. 423, June 22, 1901. Paper read before the American Society of Mechanical Engineers at Milwaukee, May, 1901.)—The paper describes the arrangements adopted by the General Electric Company for printing by electric light. Each light consists of two 5-ampere enclosed arcs, in opal globes, with reflectors; these are suspended from trolleys running on girders along the ceiling, and are brought over the printing frame. The time required to print is about three times as long as in sunlight in February. Owing, however, to greater ease in handling, the cost is less than that of printing by sunlight, the prices being, respectively, 2·09 and 2·039 cents per print.

G. H. B.

2094. *Stereoscopic Experiments and Measures.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 21. pp. 221–224, Aug., 1901.)—The author has devised a simple apparatus without lenses or prisms. It consists of a pair of metal tubes bound together, each 1 m. in length and 55 mm. in diameter. The eye end is closed, except for a long horizontal slit 2 mm. in width. The other end has a holder for the objects which take the place of stereoscopic pictures, viz., metal plates pierced with holes, or glass plates with figures pasted on them. Outside the carrier are two long vertical pointers, whose distance apart can be altered by micrometer screws. Let E_1, E_2 be the positions of the two eyes, O_1, O_2 two objects (one in each tube) which are seen as one, P the intersection of the lines E_1O_1, E_2O_2, then P is the virtual image, and we

have $E_1P : E_1O_1 :: E_1E_2 : E_1E_2 - O_1O_2$; whence E_1P, the distance from the eye to the virtual image, is obtained. The distance between the eyes can be found by making the two pointers coincide with a very distant point. The formula shows that EP is > EO, or that the far end of the tube appears further off than it really is, with the curious result that an external object whose distance from E is < EP, appears to lie inside the tube. If the lines E_1O_1, E_2O_2 diverge, the image P falls behind the observer. The author remarks that all normal eyes are capable of diverging their axes, an action never called for by nature, though it may be—and generally is—required for uniting the stereoscopic pictures ordinarily sold. The maximum amount of divergence possible may be measured with the apparatus, by turning it upon a white surface, and screwing the pointers apart until the eyes are no longer able to see them as one. The image then suddenly appears double, and, by the help of the pointer readings at this point, the angle of divergence can be calculated. A. E.

2095. *Brightness of Vision in Men and Animals.* **A. Gleichen.** (Archiv Math. Phys. 1. pp. 238–245, July 23, 1901.)—The author first finds an expression for the brightness h of the retinal image of a small surface element normal to the axis. For the human subject, this expression reduces to $h = 0{\cdot}00496\, k\pi r^2$, r being the radius of the iris, and k a constant. For a fish, the iris being fixed, it becomes $h = 0{\cdot}213\, k\pi$. By putting $r = 2$ mm., the value corresponding to ordinary daylight, the result is arrived at that the fish sees 10·7 times as brightly as a human eye. When $r = 4$ mm. this ratio diminishes to 2·7. A. E.

2096. *New Form of Lantern Polariscope.* **F. E. Ives.** (Frank. Inst., Journ. 152. pp. 157–160, Aug., 1901.)—The instrument here described gives vertical projection, instead of horizontal, as in the usual type. This is obtained by using an inclined plane mirror, which receives the rays from the polarising bundle of glasses, and sends them vertically upwards to the objective, analyser and horizontal stage. Details and measurements are given. The transmitted light from the bundle of glasses can also be used for ordinary direct projection; by replacing the bundle by a silvered mirror ordinary vertical projection is obtained. J. W. P.

2097. *Rotatory Power of Sugar.* **H. Pellat,** (Annal. Chim. Phys. 23. pp. 289–316, July, 1901.)—This paper describes an investigation undertaken for the French Government Commission for the Unification of Methods of Analysis of Alcohols and Sugars. The sugar used in the experiments came direct from the factory, where it had been refined with special care. It gave a percentage of ash only 0·00063 of its mass. Apparatus was specially constructed for the investigation. (I.) The first step was to determine the "prise d'essai," or the mass of pure sugar which must be contained in 100 cc. of a solution at 20°, in order that a column 20 cm. in length may rotate the plane of polarisation of the D line through 21′.67. The result obtained was 16·284 gr., or, allowing for the presence of impurities, 16·275 gr. From the former number the value 66·536° is deduced for $(a)^{D}_{20^\circ}$, the rotatory power, a result practically identical with Mascart and Bénard's, which was 66·538°. (II.) For β, the coefficient of apparent variation of rotatory power with temperature, very concordant results were obtained, the mean being −0·00036 (for temps. between 14° and 30°). The expansion of the bronze containing-tube is here involved. If the coefficient of linear expansion for bronze be taken as

0·00002, and γ be the coefficient of true variation, we have $\beta = \gamma + 0{\cdot}00002$ and therefore $\gamma = -0{\cdot}00038$. For a tube of glass with coefficient 0·00001 we should have $\beta' = \gamma + 0{\cdot}00001 = -0{\cdot}00037$. Hence if R_t, the rotation for temp. $t°$, be observed, the rotation for 20° is given by $R_{20} = R_t\,[1 + 0{\cdot}00037\,(t-20)]$. (III.) As regards variation with wave-length, the following results were obtained, a being the ratio of rotation for λ, to the rotation for the mean of the D lines. The substance emitting the ray is indicated in each case.

λ	a	λ	a
Cd 0·64385 μ	0·8290	Cd 0·53790	1·2162
Ba 0·61418	0·9150	Cd 0·50859	1·3713
D 0·58930	1·0000	Mn 0·47660	1·5796
Cu 0·57002	1·0741	Cd 0·46782	1·645

The law $a \propto 1/\lambda^2$ does not suffice to represent these observations. The formula $a = A/\lambda^2 + B/\lambda^4$ was tried, and with $\log A = \bar{1}{\cdot}512529$, $\log B = \bar{3}{\cdot}879098$, gives good agreement, the greatest discrepancy being only 1/1000. A. E.

2098. *Universal Spectrometer.* **G. Melander.** (Zeitschr. Instrumentenk. 21. pp. 224–226, Aug., 1901.)—This instrument can be used for studying any portion of the spectrum, either visually, photographically, or photometrically, with two different dispersions. Relative wave-lengths, it is stated, can be determined with an accuracy of 0·015 $\mu\mu$. The spectrum is 30°, or 9 cm., in length (with two prisms), and two lines can be seen between the D lines. The four main parts of the apparatus are the polariscope, the collimator, the prism case and the camera tube. For visual work a micrometer eyepiece is attached to the end of the camera tube. The polariscope can be turned out of the way if desired ; when in use, the light from it is reflected by a prism into the upper half of the slit. The collimator lens is trebly corrected photographically. The camera lens is a Zeiss stigmatic Ser. VII. No. 5, of 36 mm. aperture, and 412 mm. focus. Two exactly similar prisms are provided, one or both of which can be used, the telescope being pushed further into the prism box in the former case. A. E.

2099. *Delicacy of Spectrum Analysis.* **W. Schuler.** (Ann. d. Physik, 5. 4. pp. 931–942, July, 1901.)—The author gives tables of the least quantities of different metallic salts required to produce the characteristic flame spectra. He finds that (1) in the two first periodic groups, the indications with the lower metals decrease in delicacy as the atomic weight increases ; (2) the delicacy, in haloid salts, diminishes as the atomic weight of the halogen increases, and in oxy-compounds as the number of atoms of oxygen is increased ; (3) the delicacy of metallic spectra is considerably lessened by mixing the coal gas with HCl or still more with vapour of chloroform. S. R.

2100. *Spectrum Analysis.* **E. Haschek.** (Akad. Wiss. Wien, Sitz. Ber. 110. IIa. pp. 181–203, Jan.–March, 1901.)—I. The author discusses the investigations of W. J. Humphreys and J. F. Mohler (Astroph. Journ. 1896, 1897) on the influence of the pressure on the wave-lengths of the arc lines, and considers the possibility of calculating the spark pressure from the displacement of the lines. The observations of F. Exner and E. Haschek on the spark spectra of the elements furnish material for the discussion. The following results are reached :—

1. In the spark spectrum considerable displacements of lines occur in

the sense of an increase of the wave-length; the analogue of those observed by Humphreys and Mohler in the arc under pressure, but they attain higher values.

2. It is supposed that the line displacements are only conditioned by a prevailing pressure in the sparks; the experimental value is determined, and the spark pressure is calculated, from the displacement in the spark, and that in the arc; then very varying values are arrived at with the same elements, always keeping to the chosen lines.

3. Lines of equal displacement in the arc appear very differently displaced and inverted in the spark. The rule that the lines of the series of Kayser and Runge show equal displacements does not hold good for the spark.

II. With regard to the dependence of the wave-lengths on the density of the incandescent vapour, the results indicate that with increasing density displacements occur, both in the case of the arc and the spark spectrum. These concern both the lines and their inversions—a phenomenon which is conditioned by the constitution of the incandescent vapour.

III. The connection of the wave-lengths with the mode of production of the incandescent vapour is next considered.

Displacements of lines in the arc and spark spectra are common, and, under certain circumstances, reach considerable magnitudes. The observed value of the wave-lengths depends in a high degree on the momentary conditions of the experiment, and these cannot always be controlled.

The question arises as to now far the wave-length data, which hold good for the transformer spectrum, are transferable to the Ruhmkorff coil spectrum. This question cannot in general be answered. The wave-lengths of the lines are to a great extent dependent upon the energy consumed. The consumption of energy is, however, greater with the transformer: somes lines, consequently, are strongly displaced towards the red. J. J. S.

2101. *Spectrum of Hydrogen from Metallic Arc.* **O. H. Basquin.** (Astrophys. Journ. 14. pp. 1–16, July, 1901.)—The author first outlines the previous work on the arc spectra of gaseous elements by Liveing and Dewar. Then follows an account of his own experiments, using a rotating metallic arc in a gas-tight chamber which could be filled with any desired medium. Examination of the spectra was made both visually and photographically with grating spectroscopes. The elements examined were aluminium, copper, magnesium, coin-silver, sodium, tin, and zinc. With the exception of sodium, all the arc spectra show $H\alpha$ and $H\beta$, and many also show $H\gamma$. $H\alpha$ is usually sharp, the others broad, hazy, and ill-defined. $H\delta$ is well shown in the spectra of tin, silver, and copper.

In addition to pure hydrogen, the lines have been observed when the arc was taken in ammonia and coal gas, and also in air, with a small jet of water playing on the poles.

Some attention is next devoted to the question of chemical action in the arc. Certain sets of lines and flutings are found which are not present in the ordinary arc taken in air, and, supposing these to be due to compounds, detailed descriptions and measures are given. A general conclusion is cited that the intensities of the hydrogen lines coming out in the arc spectra of various metals are (roughly) inversely proportional to the intensities of the characteristic flutings of these metals. Also the general effects of the hydrogen atmosphere may be summarised as follows:—(1) The arc works poorly in hydrogen. (2) The intensity of the whole spectrum is greatly

reduced in hydrogen. (3) Those metallic lines which belong to the series of Kayser and Runge are uniformly reduced in intensity. (4) Other lines are reduced in intensity but not uniformly. (5) Certain lines supposed to belong to the spark spectrum make their appearance in the arc in hydrogen.

An excellent reproduction of the photographed spectra of tin in hydrogen and aluminium in ammonia accompanies the paper. C. P. B.

2102. *Continuous Spectra of Liquids and Solids.* **L. Décombe.** (Comptes Rendus, 188, pp. 282–284, July 29, 1901.)—The author proposes to account for the continuous spectrum exhibited by an incandescent solid or liquid by assuming a special controlling action of neighbouring molecules upon each other at the superficial boundaries of the body. In the interior, the homogeneity of the molecules will cause mutual neutralisation of the disturbing forces, but at or near the free surfaces this will not be so; assuming then that each individual particle continues to radiate, the integration of the actions of all will give light of all wave-lengths. Numerical examples are given in illustration of this view. C. P. B.

2103. *Ultra-violet Spectrum of the Alternating Current Discharge.* **A. W. Wright** and **E. S. Downs.** (Amer. Journ. Sci. 12, pp. 66–78, July, 1901.)—When an induction coil is driven by an alternating current, the spectrum of the arc between the terminals of the secondary is found to give a large number of lines; it is the purpose of the paper to discover their origin, but the author's efforts are at present confined to those in the ultra-violet. Photographs under various conditions are obtained by means of a Rowland grating, the sun's spectrum being thrown on the same plate, for comparison. The lines studied come where the red of the first spectrum and the ultra-violet of the second overlap. Staining the plates with various preparations showed that they were really in the ultra-violet, extending from a wave-length of 8068 down to 8184, and this was further proved by obtaining them in the first spectrum. The lines are not due to the electrode, and the authors think they are not due to water vapour alone, but rather to the various constituent gases of the air and combinations of them which are facilitated by the presence of water vapour, consisting, probably, for the most part, of nitrogen and its oxides. R. S. W.

2104. *Spectral Lines.* **C. Runge** and **F. Paschen.** (Ann. d. Physik, 5, 8, pp. 725–728, June, 1901; also Astrophys. Journ. July, 1901.)—J. R. Rydberg suggested in 1898 that various sets of triplets observed in the spectra of calcium, strontium, zinc, cadmium, and mercury were not made up merely of three single lines, but that those lines were accompanied by feebler ones. The distances of these weaker satellites follow certain laws observed by Rydberg. The lines of mercury, according to the observations of Kayser and Runge, he finds are not arranged in the same way as those of the other elements and concludes that Kayser and Runge's observations are probably incomplete and that further observations are necessary to elucidate the complex triplets of the mercury spectrum. The authors have undertaken an investigation of the vibrations of mercury light in the magnetic field, and while their experiments are not yet complete they give some of their results in the present paper. These show that in fact the lines of the triplets observed and measured by Kayser and Runge must be supplemented by other weaker lines which accompany them. The observations of wave-lengths already made must be extended by more accurate determinations,

as it is probable that the lines referred to as single all consist of several components.

Tables of the wave-lengths of the components of the two compound triplets observed, and also of the vibration numbers, are given in the paper. With the supplementary lines found by the authors the compound triplets in the mercury spectrum are closely analogous to the compound triplets in the spectra of calcium, strontium, zinc, and cadmium, but in the spectrum of mercury there appears to be one satellite more to each main line. J. J. S.

2105. *Displacement of Cadmium Line* λ4800 *by Pressure.* **W. B. Huff.** (Astrophys. Journ. 14. pp. 40–48, July, 1901.)—The author has been employed in investigating the influence of quantity, and of secondary substances, on the displacements of spectral lines of a substance produced by pressure. He concludes that the shift does not depend on the amount of metal present, and that the effect of a strange metal is considerable. For considerable pressures the relation between pressure and displacement appears to cease being linear. C. P. B.

2106. *Standard Wave-lengths of Solar Spectrum.* **Perot** and **C. Fabry.** (Comptes Rendus, 133, pp. 153–154, July 15, 1901.)—A series of standard lines, from λ4643·645 to λ6471·885, have been measured by the interferometer, and the reduced values are compared with the values given by Rowland; the residuals are shown in a curve which shows the departure of Rowland's scale from that of a perfectly normal spectrum. C. P. B.

2107. *Energy of Röntgen Rays.* **F. Leininger.** (Phys. Zeitschr. 2. pp. 692–693, Aug. 31, 1901.)—In trying to repeat the measurements of previous experimenters on the energy of Röntgen rays, the author found that, with the same arrangement of the bridge in which the bolometer is placed, he could observe no heating effect at all when the radiation fell on the strip. A comparison of the sensibility of his instruments with those of Rutherford leads him to the conclusion that a large galvanometer deflection should have been obtained. This negative result is shown whether hard or soft rays are dealt with. The author cannot reconcile his result with the fairly concordant results of other physicists. R. S. W.

2108. *Influence of Annealing on Transparency to Röntgen Rays.* **R. Malagoli.** (N. Cimento, 1. pp. 445–452, June, 1901; Memorie della R. Acc. di Sc. Lett. ed Arti in Modena, Serie 3, vol. 3.)—Faraday found that a film of gold or silver, if annealed, became more transparent to white light and lost its metallic lustre, but regained its original character if pressed between two agate surfaces. The author finds that if any difference is caused by annealing it is in the direction of making such films less transparent to Röntgen rays. The cause of both these effects appears to be that the metal arranges itself in thickened patches separated by a network of thinned-out metal, which follows the lines of rugosities in the gold-beater's skin used in making the leaf, and as a whole tends to shrink. Where the metal is held in position, or is of an appreciable thickness, the opacity to Röntgen rays is increased. A. D.

2109. *Effect of Temperature on Radio-active Substances.* **E. Rutherford.** (Phys. Zeitschr. 2. pp. 429–431, April 20, 1901.)—The radio-active compound is heated in a platinum tube, through which a 2 c.cm/sec. current of filtered

air passes. The ionised air is received in a metal cylinder connected to one pole of a 300-volt battery, and a wire connected to an electrometer projects into the cylinder. Thorium and radium compounds were examined. These had their activities increased by heating up to a certain point: they then decreased and almost vanished and did not return on cooling. The heat effect on the emanation from radium is enormously greater than that on thorium, but, bulk for bulk, thorium is more powerful than radium at ordinary temperatures. Also the emanation from radium remains much longer active than does that from thorium, the reverse happening in the case where the activity is induced. At ordinary temps. the induced activity is always displayed by the kathode; on heating, it appears on both electrodes. Emanation is probably due to a chemical process in the material. G. E. A.

2110. *Radio-activity.* **E. Rutherford.** (Nature, 64. pp. 157–158, June 13, 1901.)—After referring to the papers by P. Curie and A. Debierne on the production of a radio-active gas obtained from radium [Abstract No. 1649, 1901], and to a paper of his own on the increase of the emanation by rise of temperature, Rutherford describes in the present article new experiments which point to the conclusion that the effects observed are due to a radio-active gas with a molecular weight probably lying between 40 and 100. The method employed was to examine the nature of the emanations from radium by measuring their rate of diffusion by an electrical method resembling that used by Loschmidt in 1870. The coefficient of diffusion of the emanation into air appears to have a value between 0·10 and 0·15, but probably nearer the former. From this value the limits of the molecular weight given above are deduced. J. J. S.

2111. *Velocity of Becquerel Rays.* **W. Kaufmann.** (Phys. Zeitschr. 2. pp. 602–603, July 13, 1901.)—A preliminary description of an investigation on the velocity of these rays and on the ratio of the electric charge of the carriers to their mass. The method is a photographic one in which the deflections due to a magnetic and an electric field are measured, and is especially designed to overcome difficulties arising from the facts that the deflected bundle gives a spectrum, and also renders the surrounding gas a conductor. R. S. W.

2112. *Uranium Radiation at very Low Temperatures.* **H. Becquerel.** (Comptes Rendus, 133. pp. 199–202, July 22, 1901.)—Observations on the uranium radiation at very low temperatures are of theoretical importance. A vertical hollow copper cylinder, closed at its lower end by thin aluminium, is placed at a short distance above a sheet of uranium, and the rate of charging of an insulated rod down the centre of the cylinder is observed. The cylinder being kept at a constant temperature, liquid air is poured over the uranium, when a large decrease in the rate of charging is found. This is due to the higher absorption of the less penetrating rays by the cold layer of air between uranium and aluminium. The final result appears to show that no alteration in the amount of radiation emitted can be found.

Dewar has shown that when a crystal of nitrate of uranium is plunged in liquid air it becomes luminous spontaneously, and attributes this to an electrical action provoked by a molecular contraction. The author has repeated the experiment, and comes to the conclusion that Dewar's explanation is the correct one. R. S. W.

2113. *Influence of Temperature on Light from Phosphorescent Bodies.* **J. Micheli.** (Archives des Sciences, 12. pp. 5–34, July, 1901.)—The author describes a number of experiments on the phosphorescence of various substances, and deduces the following conclusions: The initial intensity, the rate of diminution, and the refrangibility of the light emitted by the sulphides of the alkaline earths all vary with the temperature. The initial intensity of the light reaches a maximum at a temperature which is different for different sulphides. These sulphides have the power of storing up at a certain temperature more luminous energy than they emit at that temperature; the whole of the energy thus stored up is given up when the temperature is raised. With blue calcium sulphide the maximum of energy is emitted at a temperature between 40° and 60°, while for the energy stored up the maximum is at $-10°$ to $-20°$; this latter temperature seems to coincide with the point of maximum value of the refrangibility of the emitted radiations. Those organic compounds which are luminous at the temperature of liquid air resemble the sulphides of the alkaline earths in that they are only susceptible of emitting light between certain limits of temperature and that the initial intensity and rate at which the luminosity diminishes vary with the temperature. While some kinds of glass are non-luminous, others emit a green light when phosphorescent; the influence of temperature on the phosphorescence of glass is only felt within limits far more remote than those given above for alkaline-earth sulphides and organic compounds. T. H. P.

REFERENCES.

2114. *Passage of Light through Prisms.* **Izarn.** (Journ. de Physique, 10. pp. 494–495, Aug., 1901.)—The paper contains an analytical demonstration of the construction for the passage of light at minimum deviation through a prism. C. P. B.

2115. *Experiments with Interference Fringes.* **G. Sagnac.** (Soc. Franç. Phys., Bull. 168. pp. 3–4; Discussion, p. 4, 1901.)—The first part of the paper deals with the secondary fringes produced in a Fresnel biprism by the light reflected from the plane face. By silvering this the existence of these fringes was made very noticeable. Then a quick method of adjusting a Jamin refractometer in white light is described, and also the method of producing Jamin fringes. C. P. B.

2116. *Theory of Dispersion.* **Carvallo.** (Soc. Franç. Phys., Bull. 168. p. 2, 1901.)—A slightly modified dispersion formula is given—

$$\lambda \sin h \frac{n}{\lambda} = K,$$

and examples quoted illustrating its application in comparison with other formulæ. C. P. B.

2117. *New Radio-active Substances.* **P. Curie** and **Mme. Curie.** (Intern. Phys. Congress at Paris, Report, 3. pp. 79–114, 1900.)—A method of measuring radio-activity by means of an electrometer is described, and a list of uranium compounds and their activities is added. The report deals also with thorium, polonium, and radium, the spectrum and atomic weight of the latter, and the penetrating power and activity-inducing power of the rays. G. E. A.

2118. *Radio-active Substances and their Radiations.* **G. B. Pegram.** (Science, 14. pp. 53–59, July 12, 1901.)—A *résumé*.

HEAT.

2119. *Boiling-point Thermometers.* **O. Hecker.** (Zeitschr. Instrumentenk. 21. pp. 133-138, 1901.)—Boiling-point thermometers made of the new Jena glass were tested for constancy. It was found that the three thermometers whose behaviour was investigated, which were constructed with a boro-silicate glass of Jena, exhibited great constancy. Such boiling-point thermometers serve to determine the gravity correction of the barometer, and hence with sufficient accuracy for meteorological purposes the intensity of gravity itself. They also serve as control instruments for aneroid and mercury barometers. A table is given exhibiting the daily results of the gravity correction for each thermometer for a period of five weeks. J. J. S.

2120. *Air-Thermometer.* **A. W. Kapp.** (Ann. d. Physik, 5. 4. pp. 905–918, July, 1901.)—To make the instrument more convenient for a single observer and at the same time to ensure accuracy to the tenth of a degree in observations up to 300°, alterations are made in the construction of the Jolly air-thermometer. In particular, the air vessel and the manometer are connected by a long capillary metal tube, and a valve of special construction is placed where this enters the manometer tube; the harmful space is thus reduced to very small dimensions, and the mercury is prevented from entering the capillary tube. Calculations show that, if the temperature of the room does not vary by 3°, the harmful space may be taken at the temperature of the room, and yet the temperature determined by the simple formula $T = (H - H_0)/(\alpha H_0 - 3\beta H)$, H_0 and H being the pressures corresponding to zero and the observed temperature, α and 3β the coefficients of increase of pressure of air and of expansion of the glass of the air vessel; a correction must be applied, which, however, may be taken from a calculated table. W. E. T.

2121. *Improved Laspeyres Thermostat.* **A. Weinhold.** (Ann. d. Physik, 5. 4. pp. 943–944, July, 1901.)—The thermostat consists of two concentric glass cylinders. The outer closed annular space, from which a tubular glass condenser rises, contains sulphuric acid; the inner space is the receptacle. To ensure smooth boiling of the acid a weak current, just sufficient to cause slight electrolysis, is passed through the liquid. H. B.

2122. *Optical Pyrometer.* **L. Holborn** and **F. Kurlbaum.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 30. pp. 712–719, June 13, 1901.)—The limiting temperature which can be measured by the thermo-couple or the air thermometer is about 1,500° C., and beyond 1,200° it is very difficult to make measurements of any accuracy. The only method available for higher temperatures is photometry of the radiation of one particular wave-length. As Wien's law has been shown to hold approximately for the radiation of a black body, and as Lummer and Pringsheim have shown that a want of blackness in the radiating body has but small effect on its visible radiation, the method should give accurate results.

The authors describe a photometric device enabling two radiations to be compared with great accuracy. The radiating source is viewed through a

tube provided with internal diaphragms, a plate of ruby glass being interposed between the eye and the tube. In the opening of the central diaphragm is fixed a stirrup of platinum-iridium wire, connected with a source of current, an ammeter, and an adjustable resistance. The tube is provided at each end with spectacle lenses, arranged to give images of the radiating source and the stirrup. The stirrup appears black against a bright field, but as its temperature is raised by increasing the current a point is reached when it disappears from the field of vision, corresponding to the point of equal red radiation from the radiating source and the stirrup. This point can be determined with great accuracy. The ammeter can be calibrated in degrees of temperature by comparison with a source of "black" radiation containing a thermo-couple. The platinum-iridium wire cannot be employed for temperatures above 1,200°, but the authors substituted for it a small 4-volt incandescent lamp, with equally good results. Tables are given showing that, within the limits of experimental error, the current is a linear function of the temperature in the case of the platinum-iridium wire, and a quadratic function in the case of the glow-lamp. These relations hold between the limits of 500° and 1,500° C., the latter being the highest temperature susceptible of measurement by the thermo-couple. Extrapolating the formula, the glow-lamp can be employed for temperatures up to 2,000°, and, by weakening the radiation from the source to be measured, the ammeter can be given a second scale for higher temperatures, determined from the intensity of red radiation by the aid of Wien's law. G. H. B.

2123. *Effect of Temperature on the Thermal Conductivity of Glass.* **J. Krüger.** (Ann. d. Physik, 5. 4. pp. 919–923, July, 1901.)—The results of previous workers being very inconsistent, the author has effected a new determination of the temperature coefficient of heat conductivity. He uses the method of Christiansen for these bad conductors. Paalhorn, by his method, has obtained results inconsistent among themselves, but this is shown to be due to a defect in his apparatus. For three kinds of glass of very different composition, the final result showed that for a rise in temperature of 1°, the heat conductivity decreased by about ·031–·045 per cent. R. S. W.

2124. *Relation Between the Specific Heat of a Liquid and that of its Vapour.* **H. Mache.** (Akad. Wiss. Wien, Sitz. Ber. 110. IIa. pp. 176–180, Jan.–March, 1901.)—Assuming the potential energy of a liquid to be equal to its kinetic energy and the latter to be independent of the state of aggregation, the author concludes that the specific heat of a liquid is twice the true specific heat of its vapour, an approximate result obtained also by another method of reasoning. Comparison is made of the known specific heats for 10 substances, and numbers lying between 1·53 and 2·29 are found for the ratio. Water is, however, quite anomalous, having the ratio 2·84. R. E. B.

2125. *Specific Heat of Non-Electrolytic Solutions, II.* **W. F. Magie.** (Phys. Rev. 13. pp. 91–101, Aug., 1901.)—This is in continuation of a former paper [see Abstract No. 76 (1900)], with slightly improved apparatus and method. Solutions in water of cane sugar, dextrose, maltose, milk sugar, levulose, mannite, dulcite, resorcin, hydroquinone, pyrocatechin, and phenol were examined, and also solutions in alcohol of the last four substances. The molecular heats were found to be independent of the concentration both in aqueous and alcoholic solutions, if dilute, so that the osmotic pressure conforms to Gay Lussac's law, though Loomis has shown that it does not accurately obey

Boyle's law. Further, the molecular heats of isomers in solution may be the same in one solvent, but may differ in another, and consequently the molecular heat of a solute may differ with the solvent; hence the process of solution is not a mere passage of the molecules of the solute into a state in every way equivalent to the gaseous state, but the solvent must interact with the solute so as to change the structure and number of degrees of freedom of either or both of them.

The heat-capacity of an electrolytic solution is of the form $H + A - B\phi$, where H is the heat-capacity of the pure solvent, ϕ the dissociation-factor, and A, B constants. R. E. B.

2126. *Practical Attainment of the Thermodynamic Scale of Temperature.* **J. Rose-Innes.** (Phil. Mag. 2. pp. 130–144, July, 1901.)—The Joule-Thomson effect and $(\partial.\phi v/\partial\phi)_t$ for a gas are assumed to be functions of t, whence a characteristic of the form

$$\phi(v - \mathfrak{C}) = Rt.$$

The former function is taken to be of the form $\Sigma a_n/t^n$ and the constants are chosen so that for a particular value of t the latter function (which is $\mathfrak{C}$) is $-\Sigma a_n/(n+1)t^n$; for this three constants are found to be in general sufficient. Estimates are then made of the absolute temperature corresponding to the freezing-point both with constant-volume and constant-pressure gas-thermometers and with both hydrogen and nitrogen as the gas, and it is concluded that Chappuis's determinations of $(\partial\phi/\partial t)_v$ are not sufficiently exact. The corrections also to reduce the readings of both kinds of thermometer to the absolute scale are deduced. R. E. B.

REFERENCES.

2127. *Gas Engines Studied by the $t\phi$-Diagram.* **B. Brunhes.** (Journ. de Physique, 10. pp. 309–325, May, 1901.)—The *generic*, as opposed to the *experimental*, theory of gas- and vapour-engines is more conveniently studied by use of the $t\phi$-diagram than of the pv-diagram, as the conditions regulating the efficiency may be obtained qualitatively by inspection and without calculation. The types considered are the Otto, the Charon with both the Ganz and the Letombe systems of regulation, and the Brayton (with isopiestic combustion and not explosion).
R. E. B.

2128. *Second Law of Thermodynamics.* **O. Wiedeburg.** (Ann. d. Physik, 5. 3. pp. 514–547, June, 1901.)—*Assuming*—for the proof offered is inadequate—that Clausius' principle is expressed by $\int dQ/\vartheta < 0$, where ϑ is the temperature of the source or sink of heat as distinguished from that of the working substance, but asserting as a result of his reasoning the dependence of a change of entropy on the *mode* of a change of condition, the author discusses the formulation of, and the range covered by, the second law of thermodynamics. R. E. B.

2129. *Corrections for Thermal Losses in Calorimetry.* **J. W. Richards.** (Frank. Inst., Journ. 152. pp. 81–89, Aug., 1901.)

2130. *Electric Thermostat.* **S. W. Young.** (Electricity, N.Y., 21. p. 36, July 24, 1901. From the Journ. Amer. Chem. Soc.)—The author describes a simple thermostat, electrically controlled and heated electrically by means of incandescent lamps. The arrangement was found to be very satisfactory for temperatures such as 25° C. W. R. C.

SOUND.

2131. *Musical Intervals in Melody.* **G. Zambiasi.** (N. Cimento, 2. pp. 50–55, July, 1901.)—Cornu and Mercadier affirmed (Comptes Rendus, 1869–72) that while in harmony the actual scale of stringed instruments was $1 : \frac{9}{8} : \frac{5}{4} : \frac{4}{3} : \frac{3}{2} : \frac{5}{3} : \frac{15}{8} : 2$, in melody unaccompanied it was a comma $(\frac{81}{80})$ sharper in the third, sixth, and seventh of the scale. The author has investigated this with artistes' voices and a phonautograph, and finds the acoustic scale, not sharpened by a comma, very closely adhered to, with occasional exceptions in the sixth of the scale; but even then only in cases in which it seems to be felt that the fifth has, for the time, become a keynote. This is in accord with the difference between the ratio Ray/Doh = 9/8 and the ratio La/Sol = 10/9 : the latter ratio is too small by 81/80 to meet the requirements in such a case. The acoustic scale is therefore the true scale for melody, as well as harmony; and the Pythagorean intervals have a function limited to modulations. A. D.

2132. *Mechanical Effects of Stationary Sound Waves.* **B. Davis.** (Phys. Rev. 13. pp. 31–47, July 1901.)—This is a continuation of the experiments described in Abstract No. 88, 1901. If a small cylinder closed at one end be placed in a stationary sound wave (produced in a closed organ-pipe) it will set itself with axis perpendicular to the direction of the wave motion, and will experience a force driving the closed end towards the wall of the organ-pipe. In addition to the rotating mill previously described, there is here used a torsion balance consisting of two gelatine capsules suspended, at the end of a cardboard arm, from a fine platinum-silver wire. This, like the mill, can be moved to any part of the wave, and the force on the cylinders is thus measured. It is found that the curve obtained by plotting the rates of rotation of the mill against the distances along the wave from the node, approximates very closely to a sine curve. So also for the torsion balance, the curve of square root of torsion and distance is a sine curve, showing that the force is proportional to the square of the amplitude of vibration at any point. The effect of varying (*a*) the cross-section of the cylinders, (*b*) the pressure of the blowing, (*c*) the position of the axes of the cylinders relative to the direction of the vibrating air particles, is investigated. A rectangular parallelopiped in place of a cylinder is found, *ceteris paribus*, to give a much smaller force. The effect of density of the medium is examined by admitting various gases into the pipe. The force on the cylinder is found to be proportional, at moderate pressures, to the density of the gas. Figures and curves are given showing the relation observed between pressure of blowing and square root of torsion for air, illuminating gas, hydrogen, and carbon dioxide.

The mathematical discussion starts from Bernouilli's hydrokinetic equation—

$$\int dp/\rho = V - q^2/2,$$

in the usual notation. The integration of this by the relation $p = C\rho^\gamma$ gives, after certain approximations, $u_1^2 - u_2^2 = 2(p_2 - p_1)/\rho$ where u_1, u_2 are the velocities of the air particles just outside and just inside the closed end of the cylinder, and p_1, p_2 are the corresponding pressures. The cylinder is supposed to be lying with its axis transverse to the stream lines. Taking $u_2 = 0$, an excess pressure is arrived at which accounts for the phenomenon. If the force be measured by the torsion balance (the maximum pressure measured was 68·6 dynes per sq. cm.), the analysis leads to a value for the amplitude of the vibrating particles. Finally, similar phenomena observed by Clement, Guthrie and Kelvin, Dvořàk and Boys, are cited. J. W. P.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

2133. *Potential of a Symmetrical System.* **T. J. I'A. Bromwich.** (Phil. Mag. 2. pp. 237–240, Aug., 1901.)—In Thomson and Tait's Natural Philosophy, 1890, art. 546, expressions are given for the potential at any point in space due to a uniform circular disc of radius a and density ρ. If the point, referred to the centre of the disc as origin, and its normal as axis, be r, θ; then for $r > a$—

$$V_0 = 2\pi\rho\left(c_1\frac{a^2}{r} + c_2\frac{a^4}{r^3}P_2 + c_3\frac{a^6}{r^5}P_4 + \&c.\right);$$

for $r < a$, and $\theta > \frac{\pi}{2} < \pi$—

$$V_1 = 2\pi\rho\,.\left(a + rP_1 + c_1\frac{r^2}{a}P_2 + c_3\frac{r^4}{a^3}P_4 + \right)$$

for $\theta > 0 < \frac{\pi}{2}$—

$$V_1 = 2\pi\rho\left(a - rP_1 + c_1\frac{r^2}{a}P_2 + c_3\frac{r^4}{a^3}P_4 + \right);$$

where P_n is Legendre's coefficient of order n, and c_n is the coefficient of x^n in $(1+x)^{\frac{1}{2}}$. By the continuity of potential, V_0 should be equal to V, when $r = a$, but apparently, from the above formula, this is not the case. The writer shows, by the properties of Legendre's coefficients, that the two expressions are in fact equal when $r = a$.

Again, when $r = a$, $\frac{dV_1}{dr} - \frac{dV_2}{dr}$ should be zero because there is no surface density on the sphere $r = a$. This also is shown to be correct. S. H. B.

2134. *Maxwell's Law, $K = n^2$, and the Molecular Structure of Bodies.* **A. Batschinski.** (Zeitschr. Phys. Chem. 38. pp. 119–121, Aug. 6, 1901.)—Maxwell's formula is—

$$u = (K-1)/(K+2) \ldots\ldots\ldots\

2135. *Absolute Potential in Insulated Network containing Capacity.* **C. E. Guye.** (Comptes Rendus, 133. pp. 388–390, Aug. 19, 1901.)—Knowledge of the absolute potential in such a network enables the requisite insulation to be determined.

Consider n insulated conductors, near an indefinite plane at zero potential or completely surrounded by a conductor at zero potential, and the u conductors connected to sources of electricity without capacity.

Whatever be the law of variation of p.d. between the n conductors, the instantaneous algebraic sum of the charges will be zero. Then it is possible to determine the absolute p.d. of each conductor, given the coefficients of capacity and electrostatic induction, and the p.d.'s between the conductors. Suppose the p.d. variations slow enough for electrostatic equilibrium at each instant, the p.d.'s in terms of the time may be expressed by equations of the type $V_n - V_1 = \phi_n(t)$, and the general equations of electrostatic equilibrium are of the type $M_n = \sum_0^n{}^k \gamma_{nk} v_k$, all the terms in v_0 being by hypothesis zero. Hence, if $\Gamma_n = \sum_0^n{}^k \gamma_{kn}$, then $\sum_0^n{}^k \Gamma_k v_k = 0$; therefore $v_1 = \sum_2^n{}^k \Gamma_k \phi_k(t) / \sum_1^n{}^k \Gamma_k$.

Particular cases: 1. When each conductor is enclosed in one at zero potential, the coefficients m vanish, and therefore $\Gamma_n = \gamma_{nn}$.

2. If the conductors form a symmetrical cable, all the Γ become equal, and therefore $v_1 = \sum_2^n{}^k \phi_k(t)/n$.

3. If the nth conductor surrounds the rest, all the Γ vanish and it easily follows that the potential of the enveloping conductor is then always zero.

W. G. R.

2136. *Electromagnetic Effects of Moving Charged Spheres.* **E. P. Adams.** (Amer. Journ. Sci. 12. pp. 155–167, Aug., 1901.)—This paper describes an experimental confirmation of Rowland's results. The moving conductor which carried the charge was made up of a number of copper spheres, soldered to the ends of an equal number of brass rods, screwed into a central brass hub, like the spokes of a wheel. Two such sets of spheres were mounted on the same insulating axle, and revolved at a high speed, one set being kept positively and the other negatively charged, by brushes connected to the terminals of a storage battery giving about 18,000 volts. The magnetic system consisted of an astatic pair, the lower needle being close to the moving conductors, and the whole enclosed in a brass tube closed at its lower end by a glass plate on which were strips of tin-foil.

Results were obtained which confirm Rowland's conclusions. J. E.-M.

2137. *Form Assumed by the Free Surface of a Liquid in Presence of an Electrified Body.* **A. Sella.** (Accad. Lincei, Atti, 9. pp. 80–86, 1900.)—The liquid is assumed to be a conductor. It will then, in presence of the electrified body placed over it, acquire an induced surface charge of density σ, the effect of which is a force $2\pi\sigma^2$ acting against the force of gravity, so that the parts of the liquid near the electrified body are raised above the surrounding level, forming a convex surface. The writer assumes the electrified body to be spherical, and first tests it as a charged point, then as a sphere of finite radius. In the case of the charged point, he finds that the convex portion of the liquid is bounded by a circle of radius $h/\sqrt{7}$, where h is the distance of the point from the liquid surface of the supposed plane. Also if ρ be the radius of curvature of the convex surface, ζ_0 its highest ordinate, $\rho\zeta_0 = h^2/\sigma$.

The case of a sphere of finite radius is treated with reference to Mathieu's "Theory of the potential and its applications to electrostatics and magnetism," and with use of Mathieu's notation. The values of ρ are calculated in case of mercury for given values of h. S. H. B.

2138. *Magnetic Effect of Electric Convection.* **H. A. Wilson.** (Phil. Mag. 2. pp. 144–150, July, 1901.)—When an electrostatic charge is set in rotation, we should expect to find a magnetic effect, but Crémieu in his experiments [see Abstract No. 1666 (1900)] failed to observe both the magnetic effect of electric convection and its converse, the electrostatic effect of magnetic convection. The author discusses these experiments and maintains that Crémieu's failure is to be attributed rather to the methods employed than to the non-existence of these effects. He shows that in Crémieu's attempt to detect the electrostatic effect of a varying magnetic field, the effect of the steady magnetic field on the charging currents was left out of account, and that this latter effect is equal and opposite to the former; thus Crémieu's result really constitutes an indirect proof of the existence of such electrostatic effect, of the amount predicted theoretically. He also shows that Crémieu's experimental arrangements in repeating Rowland's experiment (Phil. Mag. 27, 1889, p. 445) were such as to cause the production of currents sufficient to compensate the desired effect, and that the partial failure when this disturbing factor was removed may be explained by the existence of defective insulation. [See also Abstract No. 1916 (1901).] W. C. H.

2139. *Magnetic Effect of Electric Convection and Crémieu's Experiments* **V. Crémieu.** (Phil. Mag. 2. pp. 235–237, Aug., 1901.)—This paper is a reply to H. Wilson's criticism of the author's experiments [see preceding Abstract]. Wilson's representation of the author's apparatus is stated to be inaccurate, as, instead of a vertical magnet, as shown, the author used a closed electromagnetic solenoid. This has zero external field, so that no electromagnetic effect on the charging current of the disc, such as Wilson suggests would be present, was possible. Wilson's second objection relates to the author's repetition of Rowland's experiment, and he suggests that insufficient insulation would account for the results. The author replies that the insulation of the parts concerned received special attention, and in further experiments, in which these parts have been completely suppressed, the same result has been obtained. He therefore abides by his former conclusions. W. C. H.

2140. *Magnetic Effect of Electric Convection.* **H. Pender.** (Phil. Mag. 2. pp. 179–208, Aug., 1901.)—After giving an account of Crémieu's experiments on this subject [see Abstracts Nos. 144 and 858 (1901)], and pointing out that the negative results of all his experiments may be due, either to the charge brushing off from the moving disc to the glass surface opposite, or from the condensing plates to the caoutchouc surface moving with the disc, the author describes the manner in which he has succeeded in observing the effect. The method employed, as in Crémieu's first experiment, consisted in measuring the current induced in a coil on reversing the convection current due to a charged rotating disc. By the use of micanite, instead of ebonite discs, change in the distance between the fixed and moving plates, due to their warping, was avoided. The author describes how the difficulties due to

mechanical jarring, direct electrostatic effect, and outside magnetic disturbances, were overcome, and calculates the connection between the deflection of the galvanometer needle and v the ratio between the two electrical units of quantity. A series of experiments gave consistent results, the mean value of v determined from them being $3{\cdot}05 \times 10^{10}$. W. E. T.

2141. *Model of a Dielectric.* **J. A. Fleming** and **A. W. Ashton.** (Phil. Mag. 2. pp. 228–233, Aug., 1901. Paper read before the Phys. Soc. of London, May 31, 1901.)—An analogy to the charge and discharge of a condenser can be found in the behaviour of wires under mechanical stress, the stress corresponding to e.m.f., elongation of the wire to electric charge, and the rate of elongation to the charging or discharging current. A simple wire does not, however, give a complete representation of the effects, as it does not show clearly the effects of time in charging the condenser. The model described consists of a series of springs, attached to, and separating, a series of pistons, the ends of each spring being fastened to pistons, placed, one above the other, in a metal cylinder containing oil. The upper pistons are made to move more easily in the cylinder than those lower down. With this apparatus, compressed electrically by means of electromagnets at the upper end, the total compression depends not only upon the compressing force but also upon the time during which it acts. The compression is measured graphically on a revolving drum. The curves given show how nearly the model is capable of imitating the behaviour of the dielectric in the charging and discharging of a condenser. R. S. W.

2142. *Electrification of Dielectrics by Mechanical Strain.* **A. W. Ashton.** (Phil. Mag. 2. pp. 233–235, Aug., 1901. Paper read before the Phys. Soc. of London, May 31, 1901.)—A sheet of indiarubber is laid between two brass-plates, connected to the quadrants of an electrometer. When a 2-lb. weight is allowed to fall from a height of a few inches on to the upper brass-plate, the needle moves quickly to the right, but immediately returns and shows a steady deflection to the left. If the sheet is stretched, there is again a deflection to the right, showing that the top plate is negative, while, if the electrometer is discharged, and the sheet allowed to collapse, there is a deflection in the opposite direction, showing a difference of potential between the plates of more than 10 volts. R. S. W.

2143. *Terrestrial Origin of Aurorœ.* **H. Stassano.** (Comptes Rendus, 133. pp. 279–281, July 29, 1901.)—With de la Rive, the author attributes the origin of the polar lights to the evaporation in the equatorial regions, and he relies on the statistics of Klein (northern polar lights) and Bollar (southern auroræ). The theory is not explained. Auroræ are very rare about the solstices, especially in July, and most frequent a little after the equinoxes, in April in the northern hemisphere, and in October in the southern; September and October are the driest months on the rainy Gulf of Guinea. In the northern hemisphere the number of auroræ averages more than thirty above lat. 60°; the corresponding line of the southern hemisphere, where climatic fluctuations are much more pronounced, keeps near the Tropic. The isothermals, isobars, and auroral frequency curves show a certain similarity, particularly in Alaska and Newfoundland. The complete paper will appear in the Annales de Géographie de Paris. H. B.

DISCHARGE AND OSCILLATIONS.

2144. *Electric Dispersion.* **A. Pochettino.** (Accad. Lincei, Atti, 10. pp. 104–109, Feb. 17, 1901; and N. Cimento, 1. pp. 453–457, June, 1901.)—Elster has found [see Abstract No. 629 (1901)] that as the relative humidity rises, the coefficient of dispersion of electricity in free air falls, whatever be the sign of the charge. This may be explained by assuming that when the aqueous vapour contained in the air is nearest to its point of condensation, a great number of the free ions existing in the air undergo a notable diminution in their mobility. These observations are important in the theory of the electric conductivity of gases, and in regard to the question of the existence of ions in ordinary air; and the author has found that the coefficients of dispersion are, within experimental errors, equal for both positive and negative charges (except on days of heavy precipitation). The nature of the ground on which the instruments are placed, or a difference in the surrounding objects, makes no difference in the value of the coefficient; and temperature, absolute humidity, force of wind, state of sky, or fall of potential appeared to produce no definite change in the value of the coefficient. In the fall of potential there were two characteristic maxima occurring at 11 a.m. and 4 p.m., and two sub-maxima at 9 a.m. and 1 p.m.; but there was nothing corresponding in the values of the coefficient of dispersion. Elster's result mentioned above is confirmed, and is general, being unaffected by the sign of the charge. During transitory showers the coefficient of dispersion rises for positive charges, and remains normal for negative charges; a result in harmony with those obtained by Elster and Geitel in the neighbourhood of waterfalls. A. D.

2145. *Diminution of Sparking Potential Difference by Magnetic Field.* **J. E. Almy.** (Cambridge Phil. Soc., Proc. 11. pp. 183–190, Aug. 10, 1901.)—It is known that a magnetic field, parallel or perpendicular to the direction of the discharge in a vacuum tube, may, if in the neighbourhood of the kathode, produce a diminution in the voltage required to produce the discharge. There is certain critical intensity of the field for which this diminution is very large. The effect is not produced at relatively high pressure; it has a very close connection with the form of the discharge. Surrounding the tube with tin-foil produces the same fall in voltage as does the magnet, when the foil is absent, but when the foil is present the magnet has no effect. When the anode surrounds the kathode similar, but more marked, results are obtained, so that the influence of the field is not due to a static charge on the walls of the tube, but is apparently dependent on the concentration of the current into a kind of brush, or arc, discharge. R. S. W.

2146. *Free Ions in the Atmosphere.* **H. Ebert.** (Archives des Sciences, 12. pp. 97–117, Aug., 1901.)—Experiments were made with an electrometer of the Elster and Geitel pattern, and with a more portable instrument of the author's. A long horizontal tube serving as a screen is fixed to the neck of the electrometer; it contains another tube resting on the electrometer rod and called the tension tube. Through this tube, air is drawn by an Assmann psychrometer, or by other means, with a velocity of from 3 to 6 cm./sec. The tension tube is charged to a potential of 200 volts. The electrometer was found to remain charged for several days after stopping the air current. The number of free ions in the air seems to increase with the purity and trans-

parency of the air and the intensity of the solar radiation; both the number of free ions and their velocity of discharge vary considerably. As regards the higher strata, see Abstract No. 1917 (1901). H. B.

2147. *Dependence of Current in Gases on the Direction of the Electric Field.* **E. Rutherford.** (Phil. Mag. 2. pp. 210–228, Aug., 1901.)—It has generally been assumed that the magnitude of the current between two electrodes placed in an ionised gas is independent of the direction of the electric field, except for very small potential differences. The author shows that several conditions must be satisfied for this to hold good, and gives various experimental arrangements for studying the inequalities of the currents in the two directions. The essential conditions for obtaining unequal currents are—(1) An ionisation unsymmetrical with regard to the electrodes. (2) A disturbance of the potential gradient, due to the movement of the ions in the electric field. (3) An unequal velocity of the ions. Under these conditions the ratio of the currents between the electrodes is the same as the ratio of the velocities of the ions. The experimental arrangement given ought, therefore, to prove capable of determining the ratio of these velocities. It is found, however, that the large secondary radiation from the ionised air prevents the fulfilment of the theoretical conditions required for the calculation. Anything, such as the presence of moisture, which renders the velocities of the ions more equal, should reduce the ratio of the currents in the two directions. This is found to be the case. R. S. W.

2148. *Dielectric Cohesion of Gases.* **E. Bouty.** (Comptes Rendus, 133. pp. 213–215, July 22, 1901.)—The dielectric gas allows electricity to pass when the electrostatic field passes a certain limit. The present inquiry is as to the influence of the dielectric wall. The thickness of this wall affects the strength of the field within the flask, but the nature of the material in contact with the gas has no influence upon the strength of field required to break down the dielectric cohesion. [See also Abstracts Nos. 2443 (1900) and 860 and 1318 (1901).] A. D.

2149. *Reflection and Absorption of Kathode Rays.* **W. Seitz.** (Ann. d. Physik, 6. 1. pp. 1–33, Aug., 1901.)—When kathode rays pass through metals it may be supposed that the electrons forming the stream travel through the inter-molecular spaces, impinging on the molecules of the metal, and that, in consequence of these collisions, some are diffusely reflected back into the air, while of the remainder some are absorbed on account of their reduced velocity and others transmitted. To test this view the author especially studies the diffusion of the rays under different angles of incidence and emission, and tests the validity of Lenard's law of absorption, according to which the magnitude of the absorption is proportional to the amount of matter traversed by the electrons. The results are as follows: With perpendicular incidence the intensity of the diffused rays decreases, and is approximately proportional to the cosine of the angle of emission. With greater angles of incidence the metals behave differently from each other. Aluminium, zinc, iron, and copper give the maximum intensity in a direction making an angle of about 20° with the normal, and lying on the same side of it as if they were regularly reflected; with platinum, silver, and gold the maximum is found in a direction between the normal and the incident rays. For the former class the reflection increases with the angle of incidence, for the latter it somewhat decreases. With perpendicular incidence the reflection

increases with the atomic weight, except in the case of zinc. The absorption of the rays by thin plates of metal is largely dependent on the voltage which produces them; contrary to Lenard's law, it *increases* with the thickness of the plate; the law is therefore only a first approximation. The increase of the absorption coefficient with the thickness of the sheet cannot be explained on the supposition that, by friction with the molecules, the electrons lose their velocity, and are therefore more easily absorbed; for the deflection of the rays by an electrostatic and also by a magnetic field, both before entering and after passing through the plate, is measured, and is found to be the same for both positions. The values of the velocity and of the ratio of the mass to the electric charge agree with Lenard's determination. R. S. W.

2150. *Magnetic Deflection of Kathode Rays.* **H. A. Wilson.** (Cambridge Phil. Soc., Proc. 11. pp. 179–182, Aug. 10, 1901.)—The object of these experiments was to prove, more completely than had hitherto been done, that the ratio of the charge carried by a kathode ray particle to its mass is independent of the nature of the metal of which the kathode is composed. Strips of different metals, fastened over holes in a strip of mica, serve in turn for kathodes. They can be brought into position, and in contact with a movable wire going to the exterior, by means of an electromagnet. The beam of kathode rays so obtained is deflected by the magnetic field due to a constant current in a coil of wire. If the current in the coil is known, the deflection of the rays, and the potential difference producing the discharge, the ratio required can be found. The result shows that this is independent of the nature of the kathode. R. S. W.

2151. *Hertz Resonators.* **A. Turpain.** (Journ. de Physique, 10. pp. 425–438, July, 1901.)—If we have a resonator in a Hertzian field concentrated by two parallel wires, we must, in order to make the resonator alternately act and be extinguished, either move the resonator to and fro with its plane parallel to the plane of the two wires, or rotate it round its own centre in its own plane. At the micrometer-gap it is agreed that there is a node of stationary waves at each free end, and a loop at the opposite mid-point of the resonator; and the wave-length to which the resonator responds in twice the length of the resonator. But as there are two extinctions and two maxima in a rotation of the resonator through 360° in its own plane, it would seem that there were four concamerations in the complete circle; and if there are four equidistant micrometer-gaps in a resonator, when two of these, opposite to one another, give a maximum spark the other two give none. The author showed in 1895 that a resonator with a hiatus in it in addition to a micrometer-gap worked as easily as a complete resonator. The hiatus plays the same part as the micrometer in a complete resonator; and the spark in the micrometer-gap is greater the greater its distance from the hiatus: whence it would follow that there are nodes at the hiatus. But as the hiatus is diminished until a spark crosses it, it is found that the spark is then of the same length as the maximum spark which the micrometer-gap would have given: in which case there would appear to be loops, not nodes, at the hiatus. This needed further investigation. If a resonator be enclosed (except the micrometer-gap) in rarefied air, the luminescence of this air shows the local electric conditions of the resonator. The rarefaction must be adjusted so as to prevent the concentrating wires from themselves producing luminescence. The smaller the micrometer-spark, the more nearly is the luminescence confined to its immediate vicinity: when it is at its maximum, the luminescence may

extend from 120° to 150° to each side of it; and as the spark is being reduced or extinguished by turning the resonator, the luminescence shrinks or disappears. If a resonator with a hiatus be used in a similar way, there is a glow at the hiatus which shrinks and fades as the micrometer-spark is lengthened and disappears when this ceases, and also shrinks and fades as the resonator is turned round so as to bring the hiatus into the extinction positions. In a resonator with two micrometer-gaps at 180° to one another, these will act as hiatus and micrometer-gap indifferently, and if equal, even alternately; the gap which happens for the moment to offer the greater resistance acts as the hiatus, and at that gap the glow is seen. This glow is evidence that at the gap of greater resistance there are two *nodes* of opposite signs, at which the variations of electric density are at a maximum. The author has extended this method of research, by means of the glow in rarefied air, to the whole Hertzian field. He describes the apparatus employed. A. D.

2152. *Hertzian Waves in Storms.* **F. Larroque.** (Comptes Rendus, 133. p. 36, July 1, 1901.)—The author, led to the subject by considering the way in which certain nervous invalids feel the approach of a storm even under a clear sky, thought this might be due to Hertzian waves propagated through the middle and upper atmosphere. A simple plate of zinc, 40 cm. square, put to earth through a micrometric spark-gap, was sufficient to show the existence of such waves prior to a storm, even under a clear sky, in two notable instances in June last. The storm was actually raging at the time of observation, in the one case in the Grampians of Scotland, and in the other case among the Maritime Alps. A. D.

2153. *Oscillatory Discharges through Divided Circuits.* **T. Mizuno.** (Electrician, 47. pp. 711–713, Aug. 30, 1901.)—A mathematical article treating the case of the oscillatory discharge of a condenser through two inductive circuits in parallel. The following results are obtained: (1) In general, the current does not take a simple form, as in the case of oscillatory discharges in a single inductive circuit. But, if the time-constants of the divided circuits happen to be equal, then the circuits may be reduced to a single equivalent inductive circuit, giving rise, under a certain special condition, to simple harmonic discharge currents. (2) Each inductive circuit has its own period of oscillation, depending on its resistance and inductance, and on the capacity of the condenser. E. H. B.

2154. *Influence of Non-inductive Resistance on Oscillatory Discharge.* **T. Mizuno.** (Ann. d. Physik, 4. 4. pp. 811–814, April, 1901, and Electrician, 47. pp. 169–171, May 24, 1901.)—When a non-inductive resistance S is placed in parallel with a resistance R, through which a condenser is discharging itself, the author shows that this is equivalent to increasing R to $R + L/SC$, L being the self-induction in R, and diminishing the capacity C of the condenser to the value $C\frac{S}{R+S}$. The damping of the oscillations is increased, and the more the smaller S. If S is smaller than the limiting value required to satisfy the inequality—

$$\left(\frac{4L}{C} - R^2\right)C^2S^2 + 2LRCS > L^2,$$

then the discharge becomes aperiodic. The non-inductive resistance thus offers an easy means of varying the period of discharge.

In the Electrician the above is repeated, and it is further proved that the

frequency is a maximum when $S = L/CR$, and that the ratio of the maximum frequency of oscillations in the inductive circuit with the non-inductive coil in, to the given frequency without the coil, is

$$\sqrt{1 + R^2/E}, \text{ where } E = 4L/C - R^2.$$

Two curves are given showing the variation of frequency with S, and of the equivalent resistance with S. G. E. A.

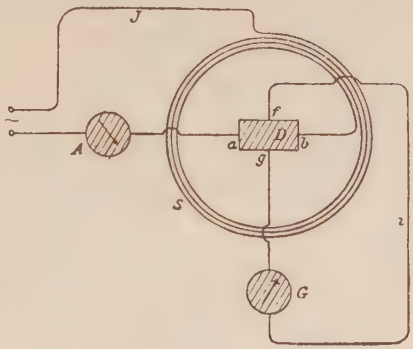
ELECTRICAL PROPERTIES AND INSTRUMENTS.

2155. *Dielectric Losses.* **C. P. Steinmetz.** (Elect. World and Engineer, 37. 1065–1066, June 22, 1901.)—The author determined the dielectric loss in condensers of tin-foil and paraffined paper, at various frequencies and voltages. He does not consider it possible to accurately measure the loss by a wattmeter, as, when the instrument is fully loaded, the reading will be very small, and it is difficult to avoid errors due to self-induction or capacity. The method adopted was to place, first in parallel and then in series with the condenser, an inductive coil, in resonance with it; in the first case the resultant current is small and practically in phase with the pressure; in the second case the resultant voltage is small and in phase with the current. In either case then, a wattmeter can accurately measure the loss in the condenser and inductive coil; non-ohmic loss in the latter was avoided by constructing it without iron, and with stranded conductors. The loss in it could therefore be measured by direct current. The following are the results obtained:—(1) With sine-wave current, the condenser current is proportional to the voltage (between 220 and 980 volts), and to the frequency. (2) The power-factor of the condenser is independent of the voltage and of the frequency. (3) The power-factor of the condensers tested averaged 0·005. The author considers the loss mainly due to traces of air occluded in the dielectric, and caused by mechanical motion of the air molecules. G. H. B.

2156. *Hall's Phenomenon in, and Resistance of, Bismuth.* **E. van Everdingen, Jr.** (Archives des Sciences, 11. pp. 433–448, 1901.)—The author's experiments were made on bars cut in different directions from the prism of crystallised bismuth employed by Perrot in his researches (Archives, vi., Aug., 1898) [Abstract No. 104 (1899)]. His conclusions are as follows: Hall's coefficient is large for a field perpendicular to the principal axis of the crystal, and very small (sometimes positive) for a field parallel to the axis; for fields of 4,600 and 2,600 units the value of the coefficient is, respectively, $-8{\cdot}2$ and $-10{\cdot}6$ perpendicular to the axis, and $+0{\cdot}6$ and $-0{\cdot}1$ parallel to the axis. The values for other directions of the field are given by the radius vector of an ellipsoid, in a way described in the paper, and showing close agreement with experiment. As regards the resistance of bismuth, when not in a magnetic field, the conductivity in any direction is proportional to the square root of the radius vector of an ellipsoid of revolution round the principal axis of the crystal, the axes being in the ratio of $\sqrt{5} : \sqrt{3}$ approximately. In a magnetic field parallel to the axis an ellipsoid with but slightly different axes gives the conductivity. In a field perpendicular to the principal axis of the crystal the three axes of the ellipsoid are different, and have values differing considerably from those of the corresponding ellipsoid with no field. The author further shows how an ellipsoid may be constructed to give the conductivity for a magnetic field of any direction. In a

plate of bismuth the resistances in two directions at right angles are not increased in the same ratio by the same field—a fact which explains the dissymmetry shown in Hall's phenomenon. G. H. B.

2157. *Conversion of Alternating into Continuous Current by Means of the Hall-Effect.* **T. des Coudres.** (Phys. Zeitschr. 2. pp. 586–590, July 6, 1901.) —The principle of the method is illustrated by the following diagram :—



The alternating current is sent through the coil S and also through the thin bismuth plate D. When this is done, the d'Arsonval galvanometer G in connection with the Hall electrodes *f* and *g* indicates a continuous current. It is obvious that this must be so, since the primary current and magnetic field change sign simultaneously. The author proves that the method is of no technical value, but is of opinion that it might come in useful for the determination of Hall constants. He also shows how the above arrangement might be used as a dynamometer, and as a direct harmonic analyser of alternating magnetic fields. F. G. D.

2158. *Thermo-magnetic and Thermo-electric Behaviour of Crystalline Bismuth.* **L. Lownds.** (Ann. d. Physik, 6. 1. pp. 146–162, Aug., 1901.) —A continuation of earlier experiments [see Abstract No. 1680 (1901)] on this subject is described. Groth, having furnished the author with a plate formed out of a large crystal of bismuth in which the crystallographic principal axis lay in the plane of the plate, an account is given of the investigations carried out with this.

I. As regards the *longitudinal effect*, it appears (1) that the curves showing the connection between the intensity of field and the longitudinal effect are of similar form for crystalline and for electrolytic bismuth, but in the former case the negative values hold with much higher temperatures. (2) In the case in which both the flow of heat and the lines of force are perpendicular to the crystallographic principal axis, positive values of the longitudinal effect exist only with the highest temperatures, and with very small intensities of field.

II. The curves relating to the *transversal effect* show that this is smaller when the flow of heat is parallel to the principal axis than when perpendicular. Whilst Yamaguchi found that with electrolytic bismuth the transversal effect continually increased with falling temperature, with crystalline bismuth it is found that in strong fields, and at very low temperatures, the effect falls off with decreasing temperature.

III. As to the *thermo-electromotive force;* this was observed for a copper

bismuth couple, the temperature differences being measured by an iron-constantan element. The formula for the e.m.f. e (in microvolts) is—

$$e = a(t_1 - t_2) + \beta(t_1^2 - t_2^2),$$

where t_1 and t_2 are the temperatures of the junctions in centigrade degrees, and a and β are constants.

Measurements were made parallel and perpendicular to the principal axis of the bismuth, with the following results :—

(1) Parallel to the crystallographic principal axis—

$$t_1 = 12{\cdot}7°,\ t_2 = 91°,\ e = 9267 \text{ MV},$$

or 118·35 MV per degree.

(2) Perpendicular to the principal axis—

$$t_1 = 15{\cdot}3°,\ t_2 = 85{\cdot}9°,\ e = 4377 \text{ MV},$$

or 61·94 MV per degree.

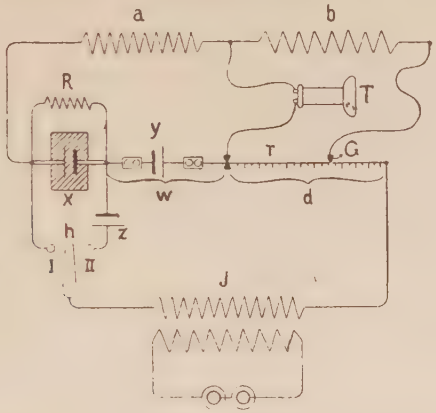
The ratio of parallel/perpendicular = 1·91. Perrot gave the value of this ratio as about 2·00. J. J. S.

2159. *Thermo-magnetic and Galvano-magnetic Effects in Tellurium.* **M. G. Lloyd.** (Amer. Journ. Sci. 12. pp. 57–63, July, 1901.)—The author gives the qualitative results of some experiments made with the idea of measuring all of the thermo-magnetic and galvano-magnetic effects in the same specimen of a non-metal, tellurium being the substance chosen. The Hall-effect is in the opposite direction from that observed in bismuth ; the galvano-magnetic difference of temperature between the edges of the plate carrying the current is in the same direction as in bismuth. When, instead of a current of electricity, a flow of heat is made to pass along the plate placed in a magnetic field perpendicular to the lines of force, the thermo-magnetic difference of potential observed between the edges is in the same direction as in bismuth, while the difference of temperature between the edges is in the reverse direction to that in bismuth. Satisfactory numerical determinations of most of these effects have not yet been obtained. W. C. H.

2160. *Electric Deformation of Glass.* **G. Ercolini.** (N. Cimento, 2. pp. 5–15, July, 1901.)—This paper contains a discussion of questions of energy and thermo-dynamics, and a description of the author's experiments. He obtains a positive value for k, *i.e.*, the dielectric constant of glass increases with the tractive stress. H. D.

2161. *New Method of Localising a Fault in a Single Cable.* **W. Betts.** (Elect. Rev. 49. pp. 255–256, Aug. 16, 1901.)—Batteries of equal, or nearly equal e.m.f., of the same kind, and of low voltage, are simultaneously applied at each end of the cable, the batteries being earthed, and the current going through the fault. Observations are numbered in order, and paired for calculation. Then, if L be the normal CR of the cable, and r and r' represent the resistances of the galvanometer, battery, and earth at the two ends respectively, and if a and b are the resistances required to represent the deflection at either end respectively, then the distances of the fault at either end will be $La/(a+b) - r$ and $Lb/(a+b) - r$, respectively. Very good results are said to be attained by this method. E. O. W.

2162. *Measurement of Accumulator Resistance.* **T. Bruger.** (Centralblatt Accumulatoren, 2. pp. 197–198, July 15, 1901.)—The method originally designed by Kohlrausch has been modified in a number of ways. The use of condensers [see Abstract No. 857 (1901)], adopted by several experimenters, has been avoided by the author in the arrangement shown. Here a and b are non-inductive resistances, x is the accumulator to be measured, which is being discharged through the resistance R, y and z are two other cells,



d a graduated bridge wire, h a two-way switch, J the induction coil, and T a telephone. A balance is first obtained in the I position of the switch, then—since R is large compared with x—

$$a/b = (x + w)/r_1 \quad \ldots\ldots(1)$$

w being the resistance of y, and r_1 that of the bridge wire between G and the end to which the telephone is connected. The switch is now thrown over to the II position, and a second balance gives—

$$(x + a)/b = w/r_2 \quad \ldots\ldots(2)$$

Hence—

$$x = a(r_1 - r_2)/(b + r_2) \quad \ldots\ldots(3)$$

Since a and b are usually large compared with r, sufficient exactness is given by—

$$x = a(r_1 - r_2)/b \quad \ldots\ldots(4)$$

If desired, the method may be modified by moving the telephone contact so as to include a portion of the bridge wire in the w circuit.

A bridge constructed by Hartmann and Braun is convenient for making the measurements. W. W. H. G.

2163. *Electroscope.* **Hurmuzescu.** (Annal. Sci. de l'Univ. de Jassy, 1. pp. 326–328, March, 1901.)—The electroscope has three metal sheets 2 millimetres apart; on the outer two are hung two gold leaves. Beneath these three sheets, and in electrical communication with the case of the electroscope, are two similar sheets, which can be moved up between the three sheets so as to form a condenser, or moved away from them. When the electroscope is to be charged, the two sheets are moved up, so that the capacity of the electroscope is large; then, if the voltage be too feeble to diverge the leaves, the two sheets are lowered, diminishing the capacity and increasing the pressure till the leaves diverge. G. H. B.

2164. *Feussner's Potentiometer.* **O. Wolff.** (Zeitschr. Instrumentenk. 21. pp. 227–231, Aug., 1901.)—The author describes an improved form of Feussner's potentiometer constructed by him, with dial switches to replace the plug switches. The dials are made with twenty segments in two series, the switch inserting resistance in one series as it cuts it out from the other. G. H. B.

2165. *Holden Phasemeter.* **P. Letheule.** (Ecl. Electr. 28. pp. 183–185, Aug. 3, 1901.)—The phasemeter for three-phase currents is based on the fact that the current in one line is in quadrature with the e.m.f. between the other two. A pair of fixed coils takes the current of one line, A, and in their field is a moving system of two coils whose zero position is perpendicular to the series coils. One coil is connected across the other two lines, B and C, so that, with no phase-lag, there is no couple on the moving system. The second coil is connected, through an adjustable resistance, between A and C; when, by reason of a phase-lag, the moving system is deflected, it is brought back to zero by adjusting the resistance, and so varying the couple on the second shunt coil. The resistance is calibrated in angles of lag. To measure angles of advance of phase, the second shunt coil is connected between A and B instead of A and C, when the same calibration applies.

The instrument can be adapted to single-phase currents by connecting the first shunt coil across the main through a coil of high self-induction, so that its current is in quadrature with the pressure. The deflection produced by a phase-lag is annulled by shunting the inductive coil by an adjustable non-inductive resistance, which can be calibrated in angles of phase. The effect of variations in frequency may be compensated by connecting the second shunt coil across the main through a condenser of suitable capacity. G. H. B.

2166. *Frequency Meter.* **R. Manzetti.** (Accad. Lincei, Atti, 10. pp. 157–163, 1901.)—The instrument has a moving system consisting of a copper disc, and a parallelopiped of laminated iron, rigidly connected one above the other, and suspended by a silk fibre ; each is acted on by an independent pair of coils. The two pairs of coils are connected in parallel across the circuit with an adjustable resistance in series with one pair. The torque exerted on the iron is independent of the frequency, while that on the copper, being due to Foucault currents, is a function of it. If then the two pairs of coils be so adjusted that for any given frequency the torques exerted by them are equal and opposite, there will be no deflection, but for a different value of the frequency a deflection will be produced, which can be annulled by adjusting the resistance in series with one pair.

If the resistances be r and r_1, and the frequency p, the author shows that $\frac{r_1^2}{r^2} = \frac{a + bp^2 + cp^4}{p^2 + dp^4}$. The measurement of the frequency is thus reduced to a zero adjustment of the instrument, and a measurement of a resistance ratio. In tests made by the author, the instrument proved correct within the limits of accuracy with which he was able to determine the frequency. The instrument can measure very low frequencies, but its readings might be falsified by self-induction at high ones. G. H. B.

2167. *Conductivity Bridge.* **R. Appleyard.** (Phil. Mag. 2. pp. 178–179, Aug., 1901. Paper read before the Phys. Soc. of London, March 8, 1901.) —The bridge is arranged so that the scale-readings on the slide-wire are

directly proportional to the conductivity of the wire under test. When used for comparing the conductivities of two lengths of wire, the arrangement is as follows: the two lengths form two adjoining arms, with the galvanometer connected to their junction; a fixed resistance and the slide-wire form the other two arms; the end of the fixed resistance being connected, not to the end of the slide-wire, but, together with the other galvanometer terminal, to the sliding contact. The author finds the best sliding contact to be a small brass bow, strung with one or more platinum wires, each of which passes once round the slide-wire. G. H. B.

2168. *High Electrical Resistance.* **O. N. Rood.** (Amer. Journ. Sci. 12. pp. 91–97, Aug., 1901.)—The author describes the continuation of his experiments on the measurement of high resistance [see Abstract No. 110 (1901)], and explains how it is possible to take a low standard resistance, measured by ordinary methods employing 50 or 100 volts, and from this to build up a set of resistances, the highest of which may equal fifteen or twenty millions of megohms, the original e.m.f. being always adhered to. With such units of resistance, any resistance which lies within their range may be easily measured, employing always one and the same e.m.f. The cores of the units described are inaccessible to moisture, and in ordinary weather their accuracy is not interfered with by surface conduction. The question of the invariabilty of the units during long periods of time is still under investigation. Details of the construction of the electrometer (similar to that already described in the former paper), of the condensers, and of the units of resistance, are given in the paper. J. J. S.

2169. *Rectifier for Polyphase Currents.* **L. H. Haynes.** (West. Electn. 29. pp. 99–100, Aug. 17, 1901.)—This paper contains a description of an experimental rectifier for use on a two-phase circuit. Each phase is rectified individually by its own two-part commutator, and the two circuits are connected in series on the direct-current side. The phases are short-circuited when the e.m.f. passes through zero, the time of short-circuit being capable of adjustment by means of a second brush. B. P. S.

ALTERNATING CURRENTS AND MAGNETISM.

2170. *Approximate Power Measurement in Three-phase Circuits.* **G. Stern.** (Elektrotechn. Zeitschr. 22. pp. 577–580, July 18, 1901.)—The author discusses the errors to which certain forms of three-phase supply meters are subject, and gives a full theoretical discussion of one recently patented device. He points out that none of the meters whose construction depends on equality of the three p.d.'s are reliable, and that the power in an unbalanced three-phase circuit can only be satisfactorily measured by means of at least two instruments. A. H.

2171. *Power Measurement in Polyphase Circuits.* **J. A. Fleming.** (Electrician, 47. pp. 407–409, July 5, 1901.)—The ways of measuring power in polyphase circuits by means of wattmeters are first described. Various methods are then given of finding the power expended in a mesh-connected three-phase system. An extremely simple solution is given of the problem of finding the currents in a mesh connection when the currents in the mains are known. If A, B and C are the effective currents in the mains, and X, Y and Z those in the delta branches, then if the latter have equal phase differences we have

to solve the following equations in order to find X, Y and Z in terms of A, B and C :—

$$X^2 + XY + Y^2 = A^2,$$
$$Y^2 + YZ + Z^2 = B^2,$$
$$Z^2 + ZX + X^2 = C^2.$$

Instead of solving the equations algebraically the author draws three lines from a point 0 making angles of 120° with each other, and then constructs a triangle whose sides are A, B and C on tracing paper. Placing the tracing paper over the other, the line A is moved about with its ends on two of the lines until the vertex of the triangle lies on the other line. When this is the case, the lines from 0 to the vertices of the triangle give X, Y and Z in magnitude and phase. A. R.

2172. *Alternating Current and Power Wave Recorders.* **É. Hospitalier.** (Soc. Int. Élect., Bull. 1. pp. 339–358, July, 1901. Also Ind. Elect. 10. pp. 295–300, July 10; and 323–326, July 25, 1901.)—Various novel applications of stroboscopic methods to the study of alternating currents are first given. A. Samojloff has noticed that the light from an ordinary glow-lamp with a fine filament on an alternating current circuit fluctuates with a frequency which is double that of the current. The experiment can easily be repeated with a teetotum made of a disc of carboard mounted on a cork with a pointed wooden match for a spindle. The disc has three white and three black sectors. When spinning rapidly it appears gray, as it slows down the sectors appear to rotate, then become stationary, the rotation then reverses, after which the disc again appears gray. A similar method is employed to determine the slip of an asynchronous motor, a card with white and black sectors on it being fixed on the axis of the rotor and illuminated by a glow-lamp on the supply circuit. The apparent angular velocity of the sectors is equal to the slip. The "Arcoscope" is an instrument perfected by the author for studying the variations in the light of the alternating current arc. By means of a circular metal disc with slots in it driven by an asynchronous motor, he shows all the variations in the light of the arc taking place during a period of fifteen seconds. The "ondograph or cymatograph" is an instrument that gives a record drawn in ink of the shape of an alternating current wave. It is not as accurate as the oscillograph, but it gives a permanent record very rapidly, and is not easily damaged. Its principle is not unlike that of the Laws recorder [see Abstract No. 1126 (1901)]; but instead of the brushes being made to move uniformly round a contact wheel, a commutator is coupled to a synchronous motor in such a manner that when the motor makes n revolutions the commutator makes $n-1$. No photography is used and the wave is recorded on paper coiled on a Kelvin rotating cylinder. A complete curve with a base 9·6 cms. long can be traced out in fifteen seconds; hence a useful record of the phenomena that happen over a period of fifteen minutes can be recorded on a band of paper 6 metres long. A novel instrument described is the "electrodynamograph," or power wave recorder. It is similar to an Elihu Thomson watt-hour meter, mounted as a wattmeter. The brushes are suppressed, the current being led to the armature by two spiral springs, which also control its position. The series coil always carries the main current, but the p.d. is only applied across the armature at momentary intervals. The angular displacement of the armature is proportional to the power at any instant, and its maximum value is about 10 degrees. The pen of the recorder is controlled by the armature. Power curves traced by the instrument are given. A. R.

2173. *Phase-turning Apparatus.* **A. Campbell.** (Phys. Soc., Proc. 17, p. 607–608, July, 1901 (Abstract).)—When a small voltage is to be measured in an electrostatic voltmeter, it is often convenient to add to it a known voltage, so as to bring the deflection to an open part of the scale. In the case of alternate currents, the added voltage must be in phase with that to be measured, and the arrangement enables the phase of the added voltage to be turned till this condition is realised. G. H. B.

2174. *Duality in Electrical Theory.* **H. Sire de Vilar.** (Écl. Électr. 28. p. 236–250, Aug. 17, 1901.)—In this paper the author extends the principle of duality [see Abstract No. 1666 (1901)] to the theory of alternating currents. The ordinary equation to an inductive circuit is—

$$e = Ri + L\frac{di}{dt},$$

assuming that e is a sine wave, it easily follows that—

$$i = Ke + C\frac{de}{dt},$$

where $K = R/(R^2 + L^2\omega^2)$ and $C = -L/(R^2 + L^2\omega^2)$, ω being written for 2π times the frequency. The author calls K the fictitious conductance and C the fictitious capacity of a circuit. The impedance (M) is $\sqrt{R^2 + L^2\omega^2}$, and the imaginary impedance (M′) is $R + L\omega\sqrt{-1}$. The reciprocal (N) of the impedance is $\sqrt{K^2 + C^2\omega^2}$ and the reciprocal (N′) of M′ is $K + C\omega\sqrt{-1}$. We always have $N = 1/M$ and $N' = 1/M'$. Employing the same notation as in Abstract No. 1666, we get—

$$e_1 + e + \left(Ri + L\frac{di}{dt}\right) = 0,$$

or for sine curves— $$e_1 + e + \left(R + L\omega\sqrt{-1}\right)i = 0,$$

i.e.— $$e_1 + e + M'i = 0 \quad \ldots\ldots(1)$$

The reciprocal of this equation is—

$$i_1 + i + N'e = 0 \quad \ldots\ldots(2)$$

Hence the equations are of the same form as for direct currents. The vector diagrams of equations (1) and (2) are triangles. The watts in an alternating current circuit are given by the equation—

$$\frac{1}{T}\int_0^T e\,i\,dt = VA\cos\phi,$$

where ϕ is the phase difference between e and i, and V and A are their effective values. If ϕ is an acute angle, the power is positive; if a right angle, it is zero; and if obtuse, the power is negative. Eliminating M′ and N′ between equations (1) and (2), we get—

$$e_1 i_1 + e_1 i + e i_1 = 0.$$

A rule is deduced for distinguishing whether the circuit is acting as a generator or as a motor. The reciprocal relations between motor and generator circuits are given, and it is shown that every theorem proved for an electrical circuit has a correlative theorem in the reciprocal circuit. For example, a circuit in which the e.m.f. is constant has for its reciprocal a

circuit in which the p.d. is constant. An example is fully worked out. The characteristic curves are drawn by the bipolar method which Blondel also employs [see Abstract No. 1127 (1901)]. A. R.

2175. *Effect of Magnetisation on Young's Modulus.* **K. Tangl.** (Ann. d. Physik, 6. 1. pp. 34–64, Aug., 1901. From a paper read before the Ungar. Akad. Wiss. Jan. 22, and May 21, 1900.)—The basis of the author's method of experiment is as follows: If a wire is magnetised under constant stretching force, it alters its length; if it is magnetised, on the other hand, so that its length remains constant, then the stretching force alters. The ratio of the two alterations is proportional to the elasticity-modulus for the chosen magnetisation. The author used thin wires of about 0·1 mm. diameter. The wires were stretched vertically, and a bifilar suspension was employed, consisting usually of platinum wires 60 cm. long, with small cross-pieces every 2 cm. Variation of length of the wire or of stretching force was indicated by the torsion of the suspension, and the method by which, in either case, the original equilibrium was restored gave the actual measure of the particular variation. These detailed arrangements are fully described. With nickel wire Young's modulus rises with the magnetising force, increasing by 1·5 per cent. as the force rises from 160 to 470 c.g.s. units. For iron the modulus is a maximum for H = 286 c.g.s. units, decreasing for stronger magnetisation. The stretching forces, however, in these experiments were small, and as the results are contrary to those of some other experimenters, the author investigated further the effect of the stretching force, using forces from 75 to 900 grammes. He finds that the effect of magnetisation on Young's modulus depends greatly on the stretching forces used, and upon the previous history (as regards stretching) of the wire. W. C. H.

2176. *Change in Steel Magnets. I.* **I. Klemenčič.** (Ann. d. Physik, 6. 1. pp. 181–191, Aug., 1901.)—The author measured the loss of magnetic moment with time in steel-bar magnets. Bars of silver steel were hardened in water at a white heat, and, after a certain number of minutes, T were magnetised; the moments were measured at different times, t, after magnetising. The loss of moment is less, the longer T is; for T = 1, the loss after 119 minutes was 11·5 per cent., for T = 60, the loss was 2·2 per cent. If, however, t be reckoned from the time of hardening and not from that of magnetising, the rate of loss of moment for any value of t is approximately independent of T. This tends to show that the loss of moment is due to after-effects of the hardening, and not, except to a small degree, to those of the magnetising. The rate of loss of moment is rapid at first, and gradually diminishes.

The percentage loss is less the greater the ratio of the length to the diameter of the bar. The rate of loss is different in different kinds of steel, and the form of the curve of moments and time is different. In unhardened steel, or in steel hardened at a low red heat, there is no perceptible loss of moment. In steel hardened at a bright red heat, though the moment acquired is only slightly greater, the loss after 49 minutes was 4 per cent. There appears, therefore, to be a critical point in the temperature of hardening, below which the moment remains constant. The after-effects of hardening are hastened, but not changed, by heating at 100°C. A bar, magnetised one minute after hardening, had a moment represented by 937·5; after 8 hours' heating the moment was 538·5, and showed no decrease after 48 hours. A second similar bar was heated for 8 hours

ter hardening, and then magnetised; the moment was 907·5, and showed decrease of about ¼ per cent. after 48 hours, attributed by the author after-effects of magnetisation. G. H. B.

2177. *Magnetic Properties of New Kinds of Iron.* **E. Gumlich** and **E. Schmidt.** (Elektrotechn. Zeitschr. 22. pp. 691–698, Aug. 29, 1901. Communicated by the Physikalisch-Technische Reichsanstalt.)—Measurements were made on ellipsoids by the magnetometric method, and also on bars by the Stroke-method. The effect of repeated annealing was tried, the specimens being heated to about 950° C. in the furnaces of the Royal Porcelain Manufactory, and allowed to cool for three days. In Walz-iron, a very pure and soft material, the annealing had but little effect. In cast-iron, however, the effect is very marked, and is reached in one annealing; the coercive force is reduced in some cases to one-third, the hysteresis to one-halt; repeated annealing diminishes rather than increases the effect. In steel the effect of annealing was very varied, depending on the quality of the steel. In dynamo sheet-iron, the first annealing improved the magnetic properties, while a second had the opposite effect. This iron was found to be very sensitive to mechanical handling; cleaning off the oxidised surface by emery cloth was sufficient to increase the energy loss by 26 per cent. From this the authors think it probable that the magnetic properties of iron when built up into an armature are inferior to those of the sheet when tested previously. Experiments on a 3 cm. steel rod showed that the effect of one annealing did not penetrate to the axis. Measurements of the electrical resistance of different irons showed that in general this was higher the higher the hysteresis loss, and the less the maximum permeability; this does not, however, apply in individual cases. A certain iron, of secret composition, which was submitted for test, had three times the average resistance of other irons, while showing a large permeability and low hysteresis loss.

Details are given of the methods employed in measuring the different quantities; and very complete tables of values for many different sorts of iron and steel. The following is a summary of some of the results:

Material.	B for H = 100.	B residual.	Coercive Force.	Max. μ	Hysteresis Loss (ergs).
Remscheider Dynamo steel...	17,600	8,840	1·27	3,280	12,800
Gelsenkirchener cast-steel ...	17,700	8,500	1·63	2,630	13,300
Böhler Tungsten steel	15,700	12,900	16·7	433	92,000
Remscheider Tungsten steel...	14,400	9,880	27·5	233	116,000
Kohlswa (52)	17,460	8,520	1·66	2,390	16,200
„ (50)	17,280	8,800	2·08	2,060	22,000
Walz-iron.....	17,300	8,060	0·67	4,640	5,160
„ annealed	17,270	8,650	0·69	6,050	5,070
Cast-iron	8,800	4,630	13·2	200	36,600
„ annealed	9,600	5,060	4·68	560	16,100

G. H. B.

2178. *Hysteresis Measurement.* **G. Finzi.** (Elettricità, Milan, 20. pp. 356–358, June 8, 1901.)—The method of measurement is based on the assumption that, after magnetic saturation, the hysteresis of soft iron is proportional to its coercive force. The specimen may be of any dimensions provided it can pass into the magnetising solenoid; it is magnetised till practically saturated, and the current diminished to zero and then reversed; the field required to de-

magnetise the iron is measured on an ammeter, the demagnetisation being ascertained by a magnetoscope. For soft iron the hysteresis coefficient y in Steinmetz's formula is equal to the coercive force multiplied by 0·00135.

G. H. B.

2179. *Direction of Magnetisation in Beds of Clay Baked by Lava Streams.* **B. Brunhes** and **P. David.** (Comptes Rendus. 133. pp. 155–157, July 15, 1901.)—The authors have applied Folgheraiter's ideas, [see Abstract No. 1506 (1900)] on the information as to the direction of the magnetic field during the baking of bricks to be obtained for their permanent magnetism, to the beds of clay in the Puy-de-Dôme region which have been baked by lava streams. Small cubes of the baked clay were cut out, the edges being respectively parallel and perpendicular to the present magnetic meridian and vertical, and the directions of their permanent magnetisation determined by a magnetometer method. In the case of cubes taken from the same lava stream the results agree fairly well; cubes taken, however, from different lava streams give widely divergent results, and the authors suggest that the method might be of use in determining whether two lava streams were contemporaneous or not.

W. W.

2180. *Connection between Shape of Pole-pieces and Pull of an Electromagnet.* **W. Beneke.** (Elektrotechn. Zeitschr. 22. pp. 542–544, July 4, 1901.)—The pole-pieces of tractive electromagnets are variously shaped by different makers. The author assumes that the surfaces between which attraction takes place are conical and coaxial, one being convex and the other concave. Assuming that the lines of induction run straight across between the two surfaces in a direction normal to both, and neglecting the effects of fringing, the author calculates the pull for a given total number of ampere-turns and length of air-gap in terms of the semi-vertical angle of the cone. He finds that the strongest pull is obtained when this angle is about 28° for cast-iron and about 20° for cast-steel. This conclusion is verified by experiment. The author points out that no pole-piece of irregular shape is better than a conical one, for since a definite angle is required for maximum pull, there will be only one portion of the irregularly shaped surface which will have this angle while all the other portions will have angles corresponding to smaller pulls. There is thus no advantage in using the complicated shapes adopted by some makers.

A. H.

MEDICAL ELECTRICITY.

2181. *Physiological Action of Magnetic Field.* **V. Grandis.** (Accad. Sci. Torino, Atti, 36. 9a. pp. 321–326, 1901.)—Schiff thought that exposure of a nerve to lines of force lengthened the period of latent excitation of the corresponding muscle: the author finds the results do not authorise this conclusion. When a nerve is excited by an induced current, while a portion of its length is in a magnetic field, the period of relaxation of the muscle is considerably prolonged, and the muscle does not completely regain its original length until the magnetic field is withdrawn. When the magnetic field is being formed, if the lines of force are at right angles to the nerve fibres, there is a contraction of the muscle; if they are parallel with these there is no such effect. In some cases the contraction just referred to may exist at both make and break; in some, at break only. Rhythmically inter-

upted magnetic fields may give rise to a fatigue-curve, and the muscle-nerve preparation may become completely exhausted to this stimulation, while it will still respond by another fatigue-curve to direct stimulation of the nerve by a rhythmically interrupted current, primary or induced ; reciprocally, the magnetic field, if interrupted, can elicit a rhythmical fatigue curve from a nerve and muscle already exhausted by direct stimulation. The effects of the magnetic field are in any case minute, and any change in the electric condition of the nerve is not measurable. A. D.

REFERENCES.

2182. *Fire-damp Detector.* **G. Léon.** (Comptes Rendus, 132. pp. 1408–1410, June 10, 1901.)—This apparatus is based on the difference between the electric resistances of two platinum wires both traversed by the same current and placed one in pure air and the other in the damp. A. D.

2183. *Electrolytic Condensers.* **A. Trowbridge.** (Phys. Rev. 12. pp. 359–362, June, 1901.)—Electrolytic condensers appear to have been suggested first by C. F. Varley (Phil. Trans., 1872). In the present paper A. Trowbridge shows how an artificial cable can be built up by using electrolytic cells in place of ordinary condensers. A description of Varley's artificial cable is given in "Notices of the Meetings of the Royal Institution," vol. v. 1866–1869. The e.m.f. of the battery should be kept low. A single Daniell or Leclanché cell is generally sufficient for demonstration purposes. R. A.

2184. *Ohm's Law.* **J. Stark.** (Ann. d. Physik, 5. 4. pp. 793–802, July, 1901.)—A theoretical paper on the ionic theory of conduction in metals, liquids, and gases, considered with respect to the tenability of Ohm's Law. W. C. H.

2185. *Analysis of Oscillatory Discharges by Braun Tube.* **F. Richarz** and **W. Ziegler.** (Phys. Zeitschr. 2. p. 432, 1901.)—Chiefly an answer to Simon and Reich to correct an impression that the electrostatic deviation had been observed and not the magnetic. G. E. A.

2186. *Heating of Electric Conductors.* **G. Crivellini.** (Elettricita, Milan, 20. pp. 389–391, June 22, 1901.)—The author works out a formula giving the temperature of equilibrium of a bare wire in air, when heated by the passage of an electric current. He gives two tables of the currents required to heat wires of various sizes to different temperatures, for copper and aluminium. G. H. B.

2187. *Theory of Oscillators for Wireless Telegraphy.* **G. Seibt.** (Elektrotechn. Zeitschr. 22. pp. 580–584, July 18, 1901.)—The theory of the apparatus used by Slaby as an oscillator is considered, especially with regard to the coil or "multiplier." The method of analysis is that employed by Steinmetz in his treatise on Alternating Current Phenomena. In the first part of the paper a comparison is made between a straight-wire conductor and Slaby's coil ; in the second part the investigation deals with the problem of calculating the best frequency to use with a coil of given dimensions. R. A.

2188. *Magnetic Measurement by the Ballistic Method.* **J. A. Montpellier** and **M. Aliamet.** (Électricien, 21. pp. 387–389, June 22 ; 22. pp. 2–7, July 6 ; 33–36, July 20 ; and 57–59, July 27, 1901.)—This paper describes the construction of a d'Arsonval galvanometer suitable for ballistic measurements, methods of calibration, and Rowland's, Hopkinson's and Ewing's methods of obtaining the hysteresis curves of iron. The methods of measurement are described in full detail, and are illustrated by numerous diagrams. G. H. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2189. *Constitution of Cast-Iron.* **H. M. Howe.** (Metallographist, 4. pp. 177–199, July, 1901. Paper read before the American Inst. of Mining Engineers, Richmond, Feb., 1901.)—A slowly cooled or white cast-iron free from graphite consists essentially of soft, copper-like ferrite, and hard glass-like cementite (Fe_3C); its hardness increases and its ductility decreases as the percentage of carbon increases, but the tenacity increases up to about 1 per cent. of carbon, and then decreases as the percentage of carbon is further increased. Grey cast-iron consists essentially of graphite embedded in a metallic matrix, which is similar in all respects to steel or white cast-iron. The properties of the mass should therefore be determined by two factors—(1) the percentage of combined carbon, which determines the character of the matrix, and (2) the percentage of graphite, the soft particles of which, embedded in the matrix, would seriously reduce the ductility, tenacity, and hardness of the mass.

The strongest steel is that which contains 1 per cent. of combined carbon and no graphite, and it is urged that the nearer a cast-iron approaches to this limit the stronger will it be, for the additional carbon if present as graphite would weaken the mass, and if present in the metallic matrix would reduce its tenacity. T. M. L.

2190. *Invisible Liquid Films and the Surface-tension of Liquid Precipitates in the case of Semi-permeable Membranes, Cells, Colloids, and Jellies.* **G. Quincke.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 38. pp. 858–874, July 25, 1901.)—The phenomena exhibited by such precipitates as copper ferrocyanide formed at the junction of copper sulphate and potassium ferrocyanide solutions, by jellies, colloids, and colloidal solutions, are attributed by the author to the action of capillary forces acting at the interface of two *liquid* media, which constitute (with the vapour) the coexistent phases of a two component system. The author regards colloidal solutions as pseudo-solutions, similar to milk, *i.e.*, as consisting essentially of two different phases. He regards the floating particles and the surrounding fluid as aqueous solutions of one and the same colloid, but of different concentration and viscosity. Coagulation is regarded as due to the coalescence of the liquid walls of the floating-particles, whereby a network of foam-cells is produced. When this occurs the colloidal solution becomes a jelly.

[It may be remarked that very similar views with respect to colloidal solutions and jellies have been already expressed by van Bemmelen, W. B. Hardy, and the Abstractor.] F. G. D.

2191. *Thermo-chemistry of very Dilute Solutions.* **H. v. Steinwehr.** (Zeitschr. Phys. Chem. 38. pp. 185–199, Aug. 23, 1901.)—The author first describes the method employed by him to measure very small quantities of heat evolved in such chemical reactions as the dissociation of acids. The measurement is made by means of a thermo-element; the quantity of heat to be measured being either compensated by another quantity which can be accurately determined, the thermo-element in this case being used as a null instrument, or comparison is made between the galvanometer readings

obtained with the unknown and with a known quantity of heat respectively. Two calorimeters of almost exactly equal capacity are made use of, compensation being effected by means of the one, while in the other the heat to be measured is evolved. If the latter is negative in sign, only one calorimeter is employed. An incandescent lamp, the heat from which can be exactly measured, serves as a standard. A short abstract is given of the measurements made, the full details being given in the author's Inaug.-Dissert. (Göttingen, 1900). The following are the results given :—$\partial Q/\partial b$ for sulphuric acid, for concentrations of 23–27 mols. of water to 1 of acid ; the heat of dilution of 4·50–0·10 normal hydrochloric acid ; the heats of neutralisation of barium and sodium chlorides in dilute solution ; the heat of dissociation in cals. of the following acids, the number in brackets giving the temperature at which the measurement is made, whilst $\Delta W/\Delta T$ represents the increase of the heat of dissociation per degree centigrade : Formic acid, — 366 (13·07°) ; acetic acid, — 304 (16–19°) ; dichloroacetic acid, + 1665 (10·9°) and + 1713 (17·2°), $\Delta W/\Delta T = 7·6$; propionic acid, — 243 (15·6°) and — 162 (18·67°), $\Delta W/\Delta T = 26·4$; butyric acid, + 277 (15·47°) and + 387 (19·58°), $\Delta W/\Delta T = 27$; isobutyric acid, + 535 (17·56°) and + 402 (13·1°), $\Delta W/\Delta T = 30$; valeric acid, + 911 (17·58°) and + 805 (13°), $\Delta W/\Delta T = 23$; benzoic acid, — 570 (12·74°) and — 495 (13·5°), $\Delta W/\Delta T = 100$; salicylic acid, — 1317 (13·45°) ; hydrocyanic acid, — 11100 (13–17°) ; phenol, — 5940 (14·6°) and — 6025 (11·5°) ; hydrofluoric acid, + 3006 (19·5°) ; succinic acid (one step), — 565 (16·4°), $\Delta W/\Delta T = 40$; tartaric acid (one step), — 863 (15°), — 1022 (11·2°), $\Delta W/\Delta T = 50$; boric acid (one step), — 3860 (18·2°), — 4040 (16·4°) and — 4140 (13·6°). T. H. P.

2192. *Isobaric Aqueous Solutions.* **J. A. Groshans.** (Zeitschr. Phys. Chem. 38. pp. 163–174, Aug. 23, 1901.)—If one molecule of a chemical compound of "density number" B (Groshans, S. 144. Berlin, R. Friedländer und Sohn, 1895) be dissolved in Aq water molecules, determinations for various isobaric solutions show that they are of the same density ; in two isobaric solutions B and Aq have respectively the same values. From a comparison of the two formulæ—

$$r = \frac{18Aq + A}{d} - 18Aq, \quad \text{and } d = \frac{3Aq + B\gamma}{3Aq + 3M}$$

the equation $r = A + 18M - 6B\gamma$ is derived, A being the molecular weight of the substance, r the difference between the volume of the solution and the volume of the water, γ and M numerical constants. γ, though sometimes 1, is generally $\sqrt{1·5}$; and, as this is equal to the ratio of Trouton's two constants 21·139 and 25·89, the author considers this an indication of the solution of a substance with the smaller value of the constant in a solvent with the larger value of the constant. M vanishes for bodies of the formulæ R′(OH), R″(OH)$_2$, R″(ClO$_3$)$_2$, is 1 for the combinations R′X, R″X$_2$, X being Cl, Br, I, or NO$_3$, for R‴(Cl)$_3$, R′$_2$CrO$_4$, and IO$_6$H$_5$, and — 1 for R′$_2$CO, and R′$_2$SO$_4$; while, for the fatty acids and their salts with R′, M rises by 1·25 for each additional CH$_2$, from the value 1 for formic acid. Combinations to be isobaric must have the same values for M and γ, as well as for B. Various tables are given comparing the results of calculation with experimental data. W. E. T.

2193. *Decomposition of Carbon Dioxide by Electric Discharge at Low Pressures.* **J. N. Collie.** (Chem. Soc., Journ. 79. and 80. pp. 1063–1069, Aug., 1901.)—The author sets out to decide whether, and how far, carbon

dioxide is decomposed when an electric discharge is passed through it. The gas, at a pressure of a few mm., is exposed to the discharge for varying periods, and then pumped out until several cc. are obtained. With aluminium electrodes it is found that from 65 to 70 per cent. of the gas is decomposed. If platinum electrodes are used a much smaller percentage is broken up, if the kathode is allowed to get very hot, but about the same amount if the current is made feebler. An electrodeless discharge decomposed about 60 per cent. in five minutes. By varying the conditions it is shown that there is continual decomposition and recombination. The rate of change is greatly increased by a reduction of the pressure, 10 secs. sufficing to reach the equilibrium stage at a pressure of 1 mm. R. S. W.

2194. *Relations between Physical Constants and Constitution in Benzenoid Amines.* II. **P. Gordan** and **L. Limpach.** (Chem. Soc., Journ. 79. and 80. pp. 1080–1085, Aug., 1901.)—The author gives the melting-points of two series of compounds, thirty-six in all, obtained by the replacement of the benzenoid hydrogen in formanilide and acetanilide by methyl groups. The melting-points of the acetyl derivatives are, with but one exception, higher than those of the corresponding formyl compounds. Certain numerical relations are obtained between the melting-points in the two series, and the author shows how such relations can be employed to calculate the melting-point of an unknown compound. T. H. P.

2195. *Diffusion of Hydrogen through Palladium.* **A. Winkelmann.** (Ann. d. Physik, 6. 1. pp. 104–115, Aug., 1901. Communicated in abstract to the Medical and Natural Science Society of Jena, May 17, 1901.)—The author gives the results of a number of experiments made to determine the relation between the diffusion of hydrogen through heated palladium and the pressure of the diffusing gas. He finds that the quantity of hydrogen passing through glowing palladium is not proportional to the pressure of the gas, but at low pressures is greater than would correspond with such proportionality. The numbers obtained would be well explained by supposing that dissociation of the hydrogen takes place and that the amount of diffused gas is proportional to the pressure of the dissociated molecules. It is therefore probable that glowing palladium is only traversed by atoms, and not by molecules, of hydrogen. T. H. P.

2196. *Rapid Gas Analysis by the Spectroscope.* **Berthelot.** (Annal. Chim. Phys. 23. pp. 447–482, Aug., 1901.)—A simple apparatus is figured, in which the gas is confined over mercury in a plain eudiometer tube, with a platinum wire terminal fused in the top. The other terminal is fused through one end of a glass U-tube, and the long conducting wire passes within the tube and out of the trough. This arrangement is then pushed up into the eudiometer from beneath, and enables the distance between the terminals to be varied as required. The spectroscope, with two series of prisms, clearly separated the D lines; an induction coil, with rapid interrupter, Leyden jar, and two accumulators, were used, and 5 to 10 cc. of gas were examined each time at the ordinary pressure. Each observation should last only a few seconds, to avoid decomposition of the gas and danger to the apparatus from heating. The characters and wave-lengths of the most prominent rays for a large number of gases and vapours are given, with a useful index to the lines and bands, and the substances producing them. S. R.

2197. *Separation of the Least Volatile Gases of Air, and their Spectra.* **G. D. Liveing** and **J. Dewar.** (Roy. Soc., Proc. 68. pp. 389–398, July 30, 1901.)—A diagram is given of the arrangement by which the most volatile of the gases were obtained from their solution in liquid air by fractional distillation at low pressure (Roy. Soc., Proc. 67. p. 467), and a figure of an improved apparatus now used for fractionating the least volatile portions. These are passed from a gasometer into a bulb, which is cooled till they solidify. The solid is then allowed to evaporate very slowly through an exhausted tube with terminals and the spectrum continually observed. The gas of the lowest boiling-point—in this case nitrogen—is succeeded with comparative abruptness by that of the next boiling-point, and so on, the change being indicated by the spectrum, so that the fractions can be easily stored separately. The alteration of the spectra of Xenon and Krypton by introducing a jar discharge, as noticed by Runge, is very marked, and may possibly indicate another gas. A prism spectroscope was used for the sake of more light. A table of the Xenon and Crypton rays is given; the latter agree fairly with Runge's list but are more numerous; the former differ from Erdmann's observations.

S. R.

2198. *Molecular Constitution of Supersaturated Solutions.* **W. N. Hartley.** (Roy. Dub. Soc., Proc. 9. pp. 529–542, Aug. 3, 1901.)—The view is advanced that supersaturated solutions contain, in solution, a less hydrated salt than that which usually separates from the solution, and that complete hydration does not occur until a crystal of the fully hydrated salt is added. In support of the view that a partially hydrated salt can exist indefinitely in solution, the analogous behaviour of anhydrous salts is quoted; many of these, such as anhydrous gypsum, are insoluble in water. Anhydrous manganous sulphate and anhydrous copper sulphate, when mixed with small quantities of water, set into a hard cake, which slowly becomes hydrated, and then dissolves; but the anhydrous salts do not appear to be soluble as such, and can remain for a considerable period in contact with water before becoming hydrated.

Supersaturated solutions can be prepared by the action of *cold* water on anhydrous salts, and Nicol has therefore suggested that such solutions may contain the anhydrous salt, which becomes hydrated at the moment when crystallisation takes place. This view is somewhat similar to that given above, but the fact that a supersaturated solution of sodium sulphate slowly deposits a small amount of the hydrate with $7H_2O$ affords evidence that this hydrate, rather than the anhydrous salt, is to be regarded as the chief constituent in the solution.

T. M. L.

2199. *Heat Evolution on Wetting Powders.* **C. E. Linebarger.** (Phys. Rev. 13. pp. 48–54, July, 1901.)—The author gives results of measurements of the amount of heat evolved when water, benzene, toluene, nitrobenzene, and pyridine are brought into contact with precipitated silica of two different degrees of fineness, the average diameter of the granules being in the one case 0·0005 and in the other 0·00096 cm. The results show that the proportion of liquid taken does not seem to influence the heat effect; a certain minimum quantity of liquid is necessary to produce the maximum heat change, but any excess over that amount has no perceptible influence. In general, the heat effect is greater the finer the powder. In the cases of water, toluene, pyridine, and nitrobenzene the heat effect obtained with the finer silica is about twice that with the coarser, the diameter of the granules in the latter case being about double that of the others. With benzene, however, the same

heat effect is produced with either powder. The different liquids examined do not vary much in their heat effects, the largest being obtained with water and the smallest with benzene; pyridine and nitrobenzene, although chemically allied to benzene, exhibit heat effects approaching that of water.
T. H. P.

2200. *Calculation of Heats of Solution by Kirchhoff's Formula.* **F. Jüttner.** (Zeitschr. Phys. Chem. 38. pp. 76–118, Aug. 6, 1901.)—Kirchhoff's law, $\partial Q/\partial x = RT^2(\partial/\partial T)\log(P/P_0)$ is in disagreement with von Babo's $(\partial/\partial T)\log(P/P_0)=0$, since $\partial Q/\partial x$ certainly differs in general from 0. Here Q is the heat of formation of a solution of 1 molecule of salt in x molecules of solvent at absolute temperature, T, P and P_0 being the saturation pressures at T, of the solution and the pure solvent respectively. The former law is well grounded theoretically, but direct measurements of P and P_0 seem to confirm the latter; these measurements, however, require to be exceedingly exact to give the ratio P/P_0 with the needful exactness, and may herein be deficient. The author has therefore re-examined the validity of these laws by estimating the ratio from the differences between (1) the boiling-points, (2) the freezing-points of concentrated solutions and of the solvent, and has obtained *quantitative* confirmation of Kirchhoff's law with solutions of KCl, KNO_3, and NaCl in water; *qualitative* confirmation he has also obtained with many other substances, for the full examination of which data are lacking.
R. E. B.

2201. *Physical Isomerism of Thallous Picrate.* **W. O. Rabe.** (Zeitschr. Phys. Chem. 38. pp. 175–184, Aug. 23, 1901.)—In the preparation of thallous picrate by mixing aqueous thallous hydroxide with either an aqueous or alcoholic solution of picric acid, slender yellow needles first separate out from the liquid, and when left in contact with the mother liquor these needles gradually change into red crystals. Both these forms have the composition of thallous picrate, $C_6H_2(NO_2)_3OTl$. The yellow needles are, however, triclinic, approximating to monoclinic crystals, and have the density 2·993 at 17°; the red form, on the other hand, is monoclinic hemimorphic, the density at 17° being 3·164. Neither modification is isomorphous with the rhombic potassium picrate, as is seen from the difference in shape and from the inability to form mixed crystals. The transformation of the yellow into the red form proceeds very slowly at temperatures below 50°, but more quickly when in contact with a solvent, and under the influence of light. The opposite change takes place more and more rapidly as the temperature is raised. Solubility determinations of the two forms in water and methyl alcohol show that the exact temperature of transition is 46°.
T. H. P.

2202. *Law of Physico-chemical Processes.* **G. N. Lewis.** (Zeitschr. Phys. Chem. 38. pp. 205–226, Aug. 23, 1901. Also Amer. Acad., Proc., June, 1901, trans. by E. Brauer.)—The author seeks to bring under a more general law the numerous equations and propositions of thermodynamics without loss of their concrete signification or immediate applicability. A reduction is given of the equation of Clausius for change of vapour pressure with change of temperature, by means of Poynting's equation connecting vapour pressure, total pressure, and the molecular volumes of the fluid and its vapour. However, instead of employing this equation, by means of the quantity called the "Fugacity" (previously described as the "passing-over tendency"; see Amer. Acad., Proc. 36,145, 1900, and Zeitschr. Phys. Chem. 35, 343, 1900), he pro-

ceeds to deduce other exact equations of the same form. The effect of temperature and pressure on the fugacity is determined, and a simple equation given, comprising every change of state of a simple substance. This equation is confirmed by discussing the influence of pressure, temperature, surface tension, and electrical potential on the fugacity. Finally, a method is developed for determining fugacity by means of vapour pressure. W. E. T.

2203. *Validity of the Ionisation Theory.* **L. Kahlenberg.** (Journ. Phys. Chem. 5. pp. 339–392, June, 1901.)—After alluding to the work of Dutoit and Friderich, Walden, Franklin and Kraus, and Costoro upon certain non-aqueous electrolytic solutions whose behaviour appears abnormal, according to the ionisation theory, the author describes experiments on aqueous solutions carried out in conjunction with A. A. Koch and R. D. Hall. The solutions varied from concentrated to dilute, one gramme equivalent of solute being contained in from ¼ to, say, 5,000 litres. The molecular weights were determined both by freezing-points and by boiling-points, and conductivity measurements were made both at the freezing-point and near the boiling-point. The conductivity was determined of the following salts :—NaCl. KCl, KBr, KI, $MgCl_2$, $BaCl_2$, $HgCl_2$, $KClO_3$, KNO_3, $HgNO_3$, $MgSO_4$, $ZnSO_4$, $MnSO_4$, $CdSO_4$, $NiSO_4$, $CoSO_4$, $FeSO_4$, and $CuSO_4$. Freezing-points were determined for NaCl, $MgSO_4$, $ZnSO_4$, $CdSO_4$ $NiSO_4$, $CoSO_4$, $FeSO_4$, and $CuSO_4$, and boiling-points for NaCl, KCl, KBr, KI, $MgCl_2$, $BaCl_2$, $HgCl_2$, $KClO_3$, KNO_3, $AgNO_3$, $MgSO_4$, $ZnSO_4$, $MnSO_4$, $CdSO_4$, $NiSO_4$, $CoSO_4$, $FeSO_4$, and $CuSO_4$. The results are given in full in the original paper. The main object of the author was to see to what extent the degrees of ionisation found by these four methods agree among themselves.

The agreement between conductivity at 0° and the freezing-point method is poor, even in dilute solutions. The conductivity, as a rule, seems to indicate much higher ionisation than does the freezing-point. Arrhenius originally accounted for such discrepancies by assuming polymerisation, basing this upon variation of migration numbers with concentration, as found by Hittorf, but this assumption was not consistently applied.

The boiling-point method shows irregularities which do not appear in conductivity measurements. *E g.*, in the case of NaCl, KCl, KBr, and KI, the molecular weights continually diminish with increase of concentration, finally becoming less than half the theoretical value, whereas the molecular conductivity increases with dilution. Similarly the molecular weights of $MgCl_2$ and $BaCl_2$ decrease with increasing concentration until they become less than one-third the theoretical. On the other hand, there is a fair agreement between the two methods in the case of $KClO_3$, KNO_3, and $AgNO_3$. But in the case of $MgSO_4$, $ZnSO_4$, $NiSO_4$, and $CuSO_4$, the molecular weights begin, in the dilute solution, with values above the theoretical, indicating no ionisation; they then increase with the concentration and finally decrease, after passing through a maximum, the values in the concentrated solutions becoming less than the theoretical. Yet there is no irregularity in the conductivity values. The molecular weights of the sulphates are less by the freezing-point than by the boiling-point method, so that if polymerisation is assumed this is greater at the higher temperature. A series of boiling-point determinations were also made on a solution of cane sugar, as an example of a non-electrolyte, and it was found that the molecular weight diminished appreciably as the concentration increased (212 as compared with the normal 342).

From the results obtained it follows that there are solutions which are excellent conductors and which nevertheless show normal molecular weight

of the solute. While in some cases the molecular weight increases with the concentration, thus agreeing qualitatively at least with the ionisation theory, in other cases the molecular weight decreases with increase of concentration, finally becoming less than what it ought to be, even for complete ionisation. In other cases the molecular weight at first increases with concentration and then diminishes. But the conductivity of these solutions continually increases with dilution. There are cases, however, in which the conductivity at first increases with the dilution and then decreases, *e.g.*, aqueous solutions of the alkaline hydroxides.

It follows, therefore, that there is no such connection between freezing-points and boiling-points of solutions on the one hand, and their conductivity on the other, as is claimed by the ionisation theory. Often there is not even a qualitative agreement.

It is generally considered that the ionisation theory is supported by various additive properties of electrolytes, but additive properties exist also in cases where ionisation cannot be applied. Again, heats of neutralisation are not sufficiently explained, and the ionisation theory cannot be brought into harmony with the law of mass action. Chemical reactiveness of electrolytes has been explained by ions, but, while this behaviour may be so explained, it does not necessitate the theory, for many pure bodies in which there is no ground for assuming ions are exceedingly active.

The supposed relation of ionising power to specific inductive capacity has been shown not to hold. The dependence of this same property upon the polymerisation of the solvent has been shown to be incorrect by the work of Kahlenberg and Lincoln. The theory of ionisation is supposed to be required by the second law of thermodynamics, but Clausius did not find it necessary to frame such a radical hypothesis as that of Arrhenius. Ionisation has led to Nernst's formula for the e.m.f. of voltaic cells, but this formula really involves the law of mass action, which has been shown not to hold for electrolytes.

If the ionisation theory is not true, there arises once more the original difficulty of interpreting van't Hoff's factor i in the gas equation. Of course this equation is supposed to hold strictly only for dilute solutions. One does not expect it to hold strictly with increasing concentration, but one has a right to expect that a solution should behave at least qualitatively as a gas does with increasing pressure. Apparently the factor i should never be placed equal to unity without experimental evidence, whether in connection with electrolytes or non-electrolytes.

In this theory it has been forgotten that an analogy is all that is being dealt with, and it has been pressed too far. The solution of a substance and the expansion of a gas are really very different. A gas will expand in vacuo, or into any other gas, but a substance will not dissolve in any liquid. Solution depends upon the solvent, but in the theory of solution the important *rôle* of the solvent has so far been neglected. W. R. C.

2204. *Absorption of Ionised Phosphorus Emanation in Tubes. II.* **C. Barus.** (Phil. Mag. 2. pp. 40–49, July, 1901.)—This paper deals with a continuation of the author's former experiments [see Abstract No. 1669 (1901)]. He now proceeds to discuss the absorption by surfaces, or by suspended particles, of atmospheric nuclei, producing condensation. Before passing into the colour-tube, the ionised air is made to pass through absorption-tubes of narrow bore, and it is found that whether these tubes be of glass, of impure grey rubber, of pure brown rubber, or of lead, the absorption velocity (in the absence of an

electric field) is practically the same, and is independent of the radius of the tube. With a wide tin tube, this velocity (k) is much smaller, showing the preservative tendency of dilution, but is still independent of the radius. The author proceeds to discuss these experiments mathematically, and computes curves which closely approximate to those given by observational data. He therefore concludes that his hypothesis that the loss of nuclei within the medium itself may be neglected, while the absorption effect of velocity k by the tubes is real, is one of great probability. In the case of the wide tubes where absorption velocity is small, the author adopts the recent suggestions of J. J. Thomson, Townsend, Rutherford, &c., that new ions are produced by collisions. Where the ionised air is markedly diluted, the new ions produced are in excess of the old, and the velocity would then diminish. W. C. H.

2205. *Distance between Dissociated Ions.* **R. Pauli.** (Elektrochem. Zeitschr. 8. pp. 73–74, July, 1901.)—Starting from the assumption that the energy possessed by an electrolyte in solution, in virtue of the positive and negative electric charges of its ions, is supplied by the so-called heat of solution or of dilution, the author proceeds to calculate the distance by which the dissociated ions are separated when no current is flowing through the solution. If r_1 and r_2 are the distances apart of the ions in the un-ionised and ionised molecules respectively, A the mechanical equivalent of heat and L the heat of dilution, then $1/r_1 - 1/r_2 = 981\ LA/9654^2$. The maximum value of L is about 500 cals., so that the difference between $1/r_1$ and $1/r_2$ becomes approximately $424 \times 981 \times 500/9654^2$ in c.g.s. units. Many compounds, such as hydrogen chloride and sulphuric acid, evolve heat on solution and also on dilution, so that in these cases the ions are farther apart before ionisation than after, whilst when the heat of dilution is zero the distance between the ions remains unchanged. T. H. P.

2206. *Electrocapillary Effect of Non-ionised Molecules.* **Gouy.** (Comptes Rendus, 133. pp. 284–287, July 29, 1901.)—The author employs a Lippmann electrometer with vertical capillary. Both mercury surfaces are in contact with normal Na_2SO_4 solution; the large mercury surface is kept constantly in contact with normal Na_2SO_4 solution, saturated with Hg_2SO_4. Different organic substances are added to the liquid in contact with the mercury surface in the capillary. The height of the mercury in the capillary is plotted as ordinate against p.d. as abscissa. The effect of the organic substances is to *diminish* the height (surface tension). This effect is much more marked in the neighbourhood of the surface-tension maxima, so that the organic substances lower and flatten the curve. Curves are given for phenol and isobutyl alcohol. F. G. D.

2207. *Velocity of Reaction before Complete Equilibrium and before the Point of Transition. Part I.* **M. Wilderman.** (Phil. Mag. 2. pp. 50 92, July, 1901.)—The paper opens with a thermodynamical discussion, as a result of which the author (employing Gibbs's nomenclature) arrives at the following "very remarkable and most general results":—

1. "If one and the same component is affected by two or more potentials at the same time, the condition of equilibrium is that the sum of all the potentials of the same component should be the same through the whole mass, while each of the potentials separately may change in a different direction or directions."

2. "If one and the same component is affected by two or more potentials.

unless they can by themselves be separately constant through the whole system (μ, ν), the values of each of the potentials, including (μ, ν), is not a constant quantity, but a changeable one conditioned in its value by the presence and value of the other potentials."

The main part of the paper gives an account of the continuation of the author's work on freezing-points, &c., employing more elaborate and exact apparatus. F. G. D.

2208. *Hydrogen-Chlorine Gas Cell.* **E. Müller.** (Zeitschr. Elektrochem. 7. pp. 750–752, July 4, 1901.)—A criticism of Akunoff's paper [see Abstract No. 670 (1901)]. The value of q for this cell is 36778 cal. (not 37167); the heat of formation of 3N HCl from its elements is 37854 (not 37680), and by the reduction of hypochlorous acid is 37404 cal.; it is therefore impossible from these data to determine what is the primary action that takes place in the cell, and the author suggests that, as chlorine and hypochlorous acid are both present in equilibrium in the cell, both may be regarded as undergoing direct reduction. T. M. L.

2209. *A Self-Depolarising Cell.* **G. Rosset.** (Soc. Franc. Phys., Bull. 166. pp. 1–2, 1901.)—The depolariser of this cell, ammonium cuprate, becomes reduced to cuprite, which is reoxidised spontaneously by the air at the surface of the cell while the action of the latter still goes on. The exciting liquid has ammonium chloride as its basis, and hence, at the positive pole, evolution of ammonia takes place, which goes to compensate the inevitable loss of ammonia by the depolariser. The latter is prevented from diffusing by the use of a semi-permeable colloidal membrane of copper ferrocyanide, precipitated in the wall of the porous cell; owing to the free ammonia of the depolariser, in which copper ferrocyanide is soluble, this membrane is kept in a colloidal condition, and so remains semi-permeable. When tested according to the official methods of the "Laboratoire Central d'Électricité," that is, when discharged continuously through 10 ohms, the variation in the current was less than 1 milliampere per 24 hours during the month which the trial lasted. The zinc is used up very regularly, the stick wearing away to a fine wire. When the zinc and the exciting solution are renewed, the discharge of the cell follows a curve which is similar to the original one, but 1 milliampere below it. The depolariser is, of course, inexhaustible. T. H. P.

2210. *Polarisation-Capacity of Platinum.* **P. Schönherr.** (Ann. d. Physik, 6. 1. pp. 116–124, Aug., 1901.)—The author gives the results of the study of the polarisation-capacity of cells containing 1/10-normal sulphuric acid, as free from gas as possible, the electrodes being pieces of platinum-foil, of 6 sq. cm. area, kept at a distance of 0·6 cm. apart by means of glass beads. After the cell is charged the capacity is found to fall regularly, at first quickly and afterwards slowly, from 77·1 to 43·6 microfarads after 72 hours; at the same time the apparent resistance increases. When the cell is heated the capacity is found to rise from 41·1 microfarads at 20° to 44·5 at 60°, and then to fall to 40·5 at 79°, whilst after cooling the value is 25·6 microfarads at 17·2°; repetition of this treatment gives further lowering of the capacity to 22·2. An apparent resistance of 7·16 ohms at 20° before heating is changed, after heating, to 8·69 ohms at 17·2°. These results are explained by the diminution of the gas content at the surface, between the platinum and the electrolyte, brought about by the heating. By passing

hydrogen over the surface of the electrolyte in the cell, and turning the latter so that the platinum plates come into contact with the gas, the capacity is increased from 20 to 33·4, whilst treatment with oxygen in the same way has no effect. When, by means of an auxiliary electrode placed in a beaker of the electrolyte surrounding the cell, so that the liquids inside and outside the cell are in communication, electrolytic hydrogen or oxygen is evolved at the surface of the electrodes, the capacity rises to 73·8 microfarads—a number almost equal to its initial value. The capacity of the cell with bright platinum electrodes is practically independent of the frequency of the alternating current, but when the electrodes are acted on by a constant polarising force it is found that for different frequencies the capacity is approximately proportional to $1/\sqrt{m}$, where $m/2\pi$ is the frequency. About 20 hours after the removal of the polarising force the cell returns to its original condition, in which the capacity is almost independent of the frequency. The removal of gas from the surface of the platinum can be effected by igniting the plates, and in this way results are obtained similar to those produced by heating the whole cell. T. H. P.

2211. *Dissociation-Equilibrium of Highly Dissociated Electrolytes. II.* **H. Jahn.** (Zeitschr. Phys. Chem. 37. pp. 490–503, June 18, 1901.)—In this paper a novel attempt is made to explain why the dissociation-equation in its ordinary form does not hold for highly dissociated electrolytes. In obtaining the dissociation-equation in its usual form, one of the premises is that the energy can be expressed as a linear function of the concentrations. According to Jahn this assumption is only legitimate when the forces acting between the molecules are the ordinary intermolecular attractive forces, which become vanishingly small at extremely small distances ; it is not legitimate, however, for the case of the electrostatic force acting between charged ions. Hence Jahn introduces into the energy-equation terms involving the squares and products of the ionic concentrations. [See further Abstract No. 183 (1901).]

This leads to the dissociation-equation :—

$$C^2/(c - C) \cdot \lambda^{-C} = k$$

for the case of a binary electrolyte, where C = concentration of anion or kation, c = total concentration, λ and k = constants. This equation is then tested by means of the freezing-point results of Hausrath, Abegg and Loomis, obtained with solutions of NaCl, KCl, NH_4Cl, KNO_3, $NaNO_3$, NH_4NO_3. The results appear to indicate a pretty fair agreement, assuming the above equation to be the true one. Jahn then shows that the expression for the e.m.f. of a concentration-cell takes the form :—

$$dE = \frac{mRT}{\varepsilon}\left(\frac{2dC}{C} - \frac{c - C}{c}\log\lambda\, dC\right)$$

According to this, Nernst's formula will always give results somewhat in excess of the truth ; although the difference will not be great for very dilute solutions, and is not sufficient to explain the divergences previously observed by Jahn. The latter he now ascribes to possible experimental errors, and all his previous conclusions founded thereon are withdrawn.

In the Zeitschr. Phys. Chem. (38. pp. 125–126, Aug. 6, 1901), the author makes a correction. It is pointed out that the experimental results cited in the above paper in support of his theory are not really applicable, because deviations from the simple gas laws cannot be supported by results which

themselves involve the laws. The theory proposed by the author remains, therefore, as it was, but the experimental verification is yet to be obtained.
F. G. D.

2212. *Osmotic Pressure Observation.* **M. Oker-Blom.** (Zeitschr. Phys. Chem. 37. pp. 744–750, July 12, 1901.)—A copper ferrocyanide membrane is permeable to sodium chloride, although impermeable to copper sulphate. The author finds that when dilute copper sulphate is placed on one side of such a membrane, and a concentrated sodium chloride solution on the other, the pressure on the copper sulphate side first falls, owing to water passing from it through the membrane. Sodium chloride, however, gradually permeates the membrane until the pressure due to it is the same on both sides, so that an excess of pressure is produced on the copper sulphate side.
T. H. P.

2213. *Theory of Drop Electrodes.* **J. Bernstein.** (Zeitschr. Phys. Chem. 38. pp. 200–204, Aug. 23, 1901.)—By means of a quick-acting capillary electrometer, the author observes and photographs the change of the potential difference between a drop-electrode and a layer of mercury in dilute sulphuric acid. He finds that the potential difference remains constant during the formation of the drop, but that, as soon as the latter falls, an extraordinarily quick current swing proceeds in the direction from the dropping mercury through the electrolyte to the mercury at rest. By comparison with the time-curve of the electrometer, when an e.m.f. of 1/101 of a Daniell element is included in its circuit, it can be shown that the potential difference between the surface of mercury and dilute sulphuric acid rises to 0·84 of its final value in 0·015 second. A short opposite movement of the mercury meniscus, which takes place at the beginning of the current swing, is supposed by the author to be due to the return into the capillary of the thread from which the drop is torn.
T. H. P.

2214. *Triple-points.* **G. Tammann.** (Ann. d. Physik, 6. 1. pp. 65–73, Aug., 1901.)—If a substance is polymorphic as a solid, it has several ice, hoar-frost, and transformation lines, corresponding to the possible states of equilibrium of liquid-solid, vapour-solid, solid-solid ; as well as the steam line for the vapour-liquid equilibrium. Wherever any three of these intersect is a triple-point, and the general theory of all such triple-points is here given, together with the relation between the slopes of these lines to the axes on a pt-diagram, and the slopes to the axes on a ϕv-diagram of the sides of the triangle which represents the corresponding triple-point.

A description is also given of the character of triple-point diagrams for CO_2 and trimethyl carbinol (dimorphic), water and AgI (trimorphic), methyl iodide (tetramorphic), sulphur and acetic acid.
R. E. B.

2215. *tp-Diagrams for Methyl-iodide and Acetic Acid.* **R. Hollmann** and **G. Tammann.** (Ann. d. Physik, 6. 1. pp. 74–83, Aug., 1901.)—The ice and transformation lines for methyl-iodide were investigated within the range —20° C. to 60° C. of temperature, and 1 to 3,200 kilos per sq. cm. of pressure ; the resulting diagram shows the substance to be tetramorphous within this range, and to exhibit six triple-points : (1) at 5·71° and exceedingly low pressure for vapour, liquid and A-solid ; (2) at —6·5° and still lower pressure for vapour A-solid and D-solid ; (3) at 9·1° and 210 kg./cm². for liquid, A-solid and B-solid ; (4) at 10° and 360 kg./cm². for A-solid, B-solid and D-solid ; (5) at 43·1°

and 1790 kg./cm². for liquid, B-solid and C-solid; (6) at 35·5° and 2020 kg./cm². for B-solid, C-solid and D-solid. From this we see that the D-solid cannot melt until after the transformation into one of the other solid forms, but it can vaporise directly.

Former observations on acetic acid are corrected and extended; this substance showing itself dimorphous within the range 0°–70° C. and 1–3000 kg./cm²., with two triple-points: (1) at 16·65°, and very low pressure, for vapour, liquid and A-solid; (2) at 57·5°, and 2330 kg./cm². for liquid, A-solid and B-solid.

[The authors distinguish the crystal forms by numbers, not letters as above.] R. E. B.

2216. *Accumulators of other Metals than Lead.* **S. v. Laszczynski.** (Zeitschr. Elektrochem. 7. pp. 821–827, Aug. 8, 1901.)—The use of nickel oxide, Ni_2O_3, as depolariser for the positive plate of an accumulator, has several advantages in the case of a properly constructed plate. Whereas the reduction of cuprous oxide reduces the e.m.f. produced at the negative plate by 0·95 volts, the e.m.f is increased by 0·04 volt where nickel oxide is used, as the compound is slightly endothermic and gives out energy during the reduction. The plates can be made much lighter than in the case of lead, as the metallic nickel gauze that is used as a basis for the plate is quite unattacked, and can be made of very thin wire. The negative plate is made of zinc immersed in an alkaline electrolyte; the nickel, unlike copper, is quite insoluble in the alkali, and there is no tendency for it to be deposited on the zinc. The combination has an e.m.f. of 1·84 volts, and the cell is not damaged by overcharging, by complete discharge, or by leaving uncharged. The cost of the nickel is not prohibitive, and for stationary batteries the cell is quite practicable, but for traction work the limited solubility (15 per cent.) of the zinc in the alkali requires the use of too large a bulk of electrolyte.

For traction work a combination in which the electrolyte is not chemically changed has some advantages, for it is only necessary to have enough liquid in the cell to form a conductor between the plates. Such a cell is formed by a combination of porous copper with silver oxide (Ag_2O_3), but it has an e.m.f. of only 0·95 volt. By using cadmium in the place of copper, the e.m.f. is raised to 1·5 volts. The usefulness of this type of cell is limited by the fact that the plates must be put far enough apart to prevent short-circuiting and to allow of the escape of gas-bubbles, and the quantity of liquid cannot be reduced very greatly. T. M. L.

2217. *Electromotive Activity of the Elementary Gases. Part II.* **E. Bose.** (Zeitschr. Phys. Chem. 38. pp. 1–27, Aug. 6, 1901.) *Part III.* **E. Bose** and **H. Kochan.** (l. c. 38. pp. 28–55.)—(Part II.) In Part I. of this paper [see Abstract No. 177 (1901)] the e.m.f. of a Grove gas-battery was found to rise with the time, a result confirmed by Wilsmore [see Abstract No. 906 (1901)]; the maximum now-*observed*, when the gases are under atmospheric pressure and at 25° C., is 1·1242 volts, but experiments with electrodes supersaturated by long-continued polarisation *indicate* a maximum of 1·1542 volts. Assuming the mean of these numbers, 1·1392 volts, we have 52654 calories as the free energy of formation of water. Other conclusions are that—(1) the gaseous polarisation of electrodes of noble metals is little more than a surface phenomenon; (2) at the oxygen electrode O, H_2O and H_2O_2 finally come into equilibrium together, but, at ordinary temperatures, and with small currents, only after perhaps months; (3) the H_2O_2 so formed is different in character

from ordinary H_2O_2, the former raising the potential and the latter lowering it; (4) heating lowers the potential far below that due to pure oxygen, doubtless by conversion of the one form of H_2O_2 into the other; (5) the theory of the gas-battery is not modified by the part taken by H_2O_2, provided that the state of equilibrium is presupposed.

(Part III.) When electrodes of pure gold in dilute H_2SO_4 are kept for a long time at a high p.d., their surface becomes modified, assuming first a spongy, and then a powdery character. In this state the anode (that in O_2) is singularly sensitive to the action of light. Daylight, electric arc light, magnesium light, &c.; also the violet light of the spectrum, cause diminution of the oxidation-potential; red light, obtained from the spectrum, or with lithium, or by coloured shields, raises this potential, while yellow and green lights have no sensible effect. The observed variations of e.m.f. amounted to as much as 0·1 volt. R. E. B.

2218. *Equilibrium in Gas-Electrodes.* **E. Bose.** (Zeitschr. Elektrochem. 7. pp. 817–821, Aug. 8, 1901.)—In the case of hydrogen-platinum electrodes a state of equilibrium is readily reached in which the platinum is saturated with hydrogen. Neither is any special difficulty experienced in saturating a platinum electrode immersed in hydrochloric acid with chlorine: the only by-product in this case is hypochlorous acid, and, as this is only present in very small quantities, equilibrium is reached as soon as the solution is saturated with chlorine. In the case of an oxygen electrode immersed in sulphuric acid and alkalies, however, a number of by-products, such as hydrogen peroxide and the persulphuric acids, are produced, and the electrode does not show a constant p.d. until these have been produced in the quantity required for equilibrium. When equilibrium is reached an oxygen electrode immersed in sulphuric acid will have the same e.m.f. as an electrode charged with hydrogen peroxide or persulphuric acid; but, until this state is reached, each form will have its own e.m.f. T. M. L.

2219. *Electrolytic Reduction of Nitrites.* **B. Suler.** (Zeitschr. Elektrochem. 7. pp. 831–842, Aug. 15, and 847–855, Aug. 22, 1901.)—Experiments were made on the electrolysis of potassium nitrite solution, between a platinum anode and a zinc kathode. The reduction is markedly influenced by the concentration, current density, and temperature. The highest yield of hydroxylamine is obtained by working with a 5 per cent. solution, at 0°, and a current density of $D_{100} = 2$ amperes, whilst the maximum amount of ammonia is obtained from 15–25 per cent. solutions, with the same current density. The formation of hyponitrous acid was not observed. It appears that the nitrite undergoes reduction directly to hydroxylamine and ammonia. Full details are given in the paper of the electrolyses and chemical analyses involved; there is also an historical introduction. N. L.

2220. *Electrolytic Manufacture of Grinding and Polishing Tools.* **J. Rieder.** (Zeitschr. Elektrochem. 7. pp. 765–767, July 11, 1901.)—This paper deals with the manufacture of carborundum polishing tools, and draws attention to the advantages of this substance over natural emery. The body of the tools is of metal, on which the emery or carborundum powder is fastened by depositing metal electrolytically, generally copper. The emery sand is next moistened with a solution of wax in benzene and dried, each particle thus receiving a fine coating of the dissolved material, and when mixed with graphite takes up the latter, and is rendered conductive thereby. The so-

prepared powder is spread over the article to be covered, which is placed as kathode in the plating solution. The copper deposit then fastens the particles on, and by rubbing off the upper surface of the copper the emery is laid bare, ready for use.

Comparisons show that for the same loss of weight with an electrolytic wheel 70 grammes of steel could be ground off, as against 20 grammes with an ordinary one. The chief advantage, in the opinion of the author, is the possibility of making wheels and tools of any degree of smallness and shape, which would be very difficult by the older methods. O. J. S.

2221. *Improvements in the Metallurgy of Aluminium.* **C. P. Townsend.** (Elect. World and Engineer, 38. pp. 14–15, July 6, 1901.)—The preliminary steps in the Hall process for the manufacture of aluminium, *i.e.*, the preparation of pure alumina, forms the first part of this paper. The author cites Roberts-Austen, according to whom 45 per cent. of the total expenses in the manufacture of aluminium are incurred in the purification of the alumina from bauxite.

It has been proposed to dissolve crude bauxite in a fluoride bath and by means of fractional electrolysis eliminate silicon, iron, and titanium, but without decomposing notable quantities of alumina. This method is not satisfactory, owing to the fact that the various voltages for decomposing these compounds lie so close together that they are thrown down simultaneously. C. Hall's recent patents, Niagara Falls (June 25), certainly deserve more consideration, as they promise to reduce the cost of manufacture of aluminium. The new body prepared differs considerably from pure alumina as hitherto obtained, and consists of a greyish-white crystalline body of vitreous lustre, S.G. 3·7 to 3·9, and therefore somewhere near the mineral corundum. According to Hall it contains a certain percentage of a carbide and also of a suboxide (Al_3O_4). Two processes are then described. Bauxite of the following composition was employed: Al_2O_3 60 per cent., Fe_2O_3 18 per cent., SiO_2 2–3 per cent., TiO_2 3–4 per cent., H_2O 17 per cent.

This bauxite is first calcined, mixed with 8–10 per cent. of carbon, and held in fusion in a carbon-lined electrical furnace, heated either by direct or alternating current. No aluminium is thus separated, as already shown by Moissan (Comptes Rendus, 119. p. 935.) The contained impurities are, however, reduced, and, especially in the presence of plenty of iron, settle at the bottom of the bath as a fused ferro-alloy.

The second method is similar to the first, the difference consisting in the employment of metallic aluminium in the molten bath in lieu of the current, for eliminating the undesirable metals. Instead of using pure aluminium, a ferro-aluminium containing about 50 per cent. of each component may be employed with advantage. The only element which has given some trouble is titanium, but, on the other hand, a small percentage of this body is rather advantageous than otherwise if the aluminium is to be employed for structural purposes. O. J. S.

2222. *Sulphide Ore Treatment.* **E. A. Ashcroft.** (Electrician, 47. pp. 451–453, July 12, 1901. Abstract of a paper read before the Institute of Mining and Metallurgy, June 19.)—This paper deals with the experimental work carried out by the author in conjunction with J. Swinburne, which consists essentially as follows:—

(1) Displacement of sulphur (or other elements) from combination with metals in an ore by means of chlorine gas in the dry way.

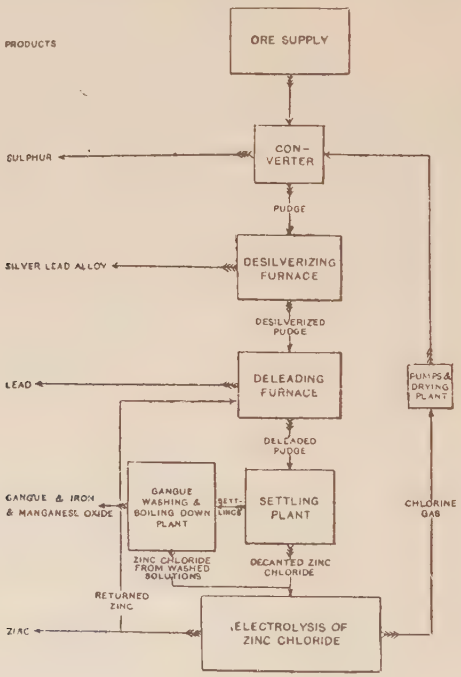
(2) Substitution of one metal for another in a mixture of fused chlorides by precipitation with a metal (or alternately the fractional electrolysis of the mixed chlorides in a fused state).

(3) Separation of siliceous gangue (which is unacted upon) from the final metallic chloride, by settling and decantation, and washing the residues in water (or alternatively by distillation of the chloride from the residues). Purifying the final chloride, boiling down the wash solutions, if any, and preparing the chloride for electrolysis.

(4) Electrolytic decomposition of the final chloride for the recovery of its metal and chlorine.

(5) Pumping the chlorine gas to a suitable pressure.

The displacement of sulphur by chlorine gas is claimed as an original discovery, as regards metallurgy, and the inventors believe that it may have an



important future, outside the limits of the particular application in their own process. The method adopted for carrying out this treatment with chlorine involves the employment of a converter, into which are introduced, at a suitable heat, the sulphides under treatment together with fused zinc chloride. The chlorine gas is then injected at the bottom and ore fed in at the top, whilst the resulting sulphur is carried away into a condensing chamber or flue, and there collected. The addition of ore to the converter and the blowing in of gas is continued until the apparatus is full of fused chlorides in liquid form, in which is suspended the siliceous gangue, which is quite unacted upon at the temperature of working. The greater part of the contents of the converter is then run off for further treatment, the remainder retaining sufficient heat to enable the process to be resumed by blowing in more gas and putting in more ore.

In a trial run lasting twelve hours, with 1,000 kg. mixed sulphide ore of the following composition—

Pb.....	29 per cent.	Gangue (by difference)	17 per cent.
Zn.....	26 „	Fe.....	5 „
S	21 „	Mn	2 „
	Ag, 19 oz. per ton.		100

470 kg. chlorine gas were used, 100 kg. sulphur were recovered, and 1,260 kg. fused chlorides were obtained, containing 23 per cent. lead, 21 per cent. zinc and 13·5 per cent. suspended gangue, in addition to iron, manganese, and chlorine. The silver in this chloride mixture amounted to 15½ oz. per ton.

The silver (and gold if present) is extracted by agitating the fused mixture with metallic lead. A rich bullion can be obtained in this way, containing the whole of the precious metals. Lead is removed by substitution of zinc, which is converted into zinc chloride and recovered in the fourth step of the complete cycle of operations. Before electrolysing the zinc chloride, it is necessary to remove all the interfering iron, which is done by the application of a blast of air at a certain stage of the converter process, the suspended Fe_2O_3 being afterwards removed from the gangue.

The removal of the gangue and oxides of iron and manganese is the thir operation. This is effected by allowing the fused zinc chloride to stand, decanting from time to time the cleared portion of the chloride, the residues being treated in one of several ways. The method usually adopted is to wash, concentrate, and remove traces of water, iron, lead, and other impurities by means of a short preliminary electrolysis with a cheap form of carbon anode, which is destroyed by the oxygen liberated, then adding the concentrated pure solution to the main bulk of zinc chloride. The advantage of this preliminary treatment is that a completely neutral zinc chloride, free from hydrogen, iron, or lead, is obtained, which does not destroy the carbon anodes of the main vat system.

The fourth and final step is the electrolysis of the fused zinc chloride, and recovery of the zinc and chlorine. This is conducted in a large steel tank, lined with 18 inches of firebricks, the inner layers of which are set in a special cement, the kathode being a mass of molten zinc and the anode consisting of a removable cast-iron plate, lined on the under side with special cement, from which depend 120 2¼-inch rods of hard carbon immersed about 6 inches in the electrolyte.

Sketch No. 2 is a diagrammatic representation of the various steps in the Phœnix process, showing that the process is truly cyclic in character.

Allowing for freight charges upon the raw ore and upon concentrates, the costs and profits, compared with the concentration process now being used for Broken Hill ores, works out as follows :—

	Net recoveries.	Total Costs.	Profit.
	£ s. d.	£ s. d.	£ s. d.
Concentration at Broken Hill and smelting in Europe or Port Pirie	2 15 0	1 15 0	1 0 0
Phœnix worked in Europe.....	8 10 0	5 5 6	3 4 6
Phœnix worked at Port Pirie	8 10 0	4 16 6	3 13 6

(Including costs of marketing products.)

An appendix and twelve plates are given with the complete paper.

J. L. F. V.

2223. *Nickel Plating and Polishing in Revolving Drums.* (Électricien, 22. pp. 101–104, Aug. 17, 1901.)—This is a description of the Delval and Pascales system of plating small articles with gold, silver, nickel, or copper in revolving drums. The special feature of the process is the commutator which supplies the current to the anode connections inside. Usually these are permanently connected to the source of current, no matter whether doing work or not. As the drum is never more than half filled with articles to be plated, only the lower bars are electrically connected with them, while the upper ones are wasting any current that may pass through them, and are receiving a coating of the metal themselves, so that they increase in size very quickly. By means of this commutator the bars not actually touching the articles in the drum are cut out of circuit, and thereby any leakage of current through them is prevented. The paper is illustrated with diagrams and views of the apparatus.
J. L. F. V.

2224. *Ozone for Sterilisation of Water.* **F. Krall.** (Elektrochem. Zeitschr. 8. pp. 99–102, Aug. 1, 1901.)—This paper contains an illustrated description of the Marmier and Abraham apparatus for water purification as exhibited by the "Soc. Industrielle de l'Ozone" at the Paris (1900) Exhibition. A detailed description of the ozoniser is followed by details of the installation at Lille, and of the results obtained there [see Abstracts Nos. 1755 and 1756 (1899)]. As regards efficiency and cost, 1 h.p.-hour is said to yield 20 grammes of ozone, and to ozonise 3·4 cubic metres of air. The actual cost of water sterilisation depends, however, largely upon the local circumstances, and no general estimate of cost is reliable. The author considers that, even when dealing with badly contaminated river water, the cost of sterilisation by ozone, added to that of the preliminary filtration through sand, would not exceed that of water drawn from distant sources.
J. B. C. K.

REFERENCES.

2225. *Electrolysis of Fused Salts.* **R. Lorenz.** (Zeitschr. Elektrochem. 7. pp. 753–761, July 4, 1901.)—A paper on the same lines as that noticed in Abstract No. 425 (1901).
N. L.

2226. *Incandescent Electric Furnaces.* **J. Joly.** (Roy. Dublin Soc., Proc. 9. pp. 482–484, July 6, 1901.)—A short description of small laboratory furnaces.
W. R. C.

2227. *Chemistry of Extreme Temperatures.* **G. Bredig.** (Phys. Zeitschr. 2. pp. 418–422, and 433-438, 1901.)—This paper is a review of the recent progress made in attaining and measuring very high and very low temperatures, and gives the latest determinations of the boiling- and melting-points of many substances. It treats also of dissociation and the solubility of gases in metals at high temperatures, electric and electrolytic conductivity, and various phenomena in thermo-chemistry.
G. H. B.

2228. *Generalisation of Clapeyron's Equation.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 393–400, June, 1901.)—Clapeyron's equation, $dp/dt = (\partial\eta/\partial v)_t$, originally given for a univariant system, is here extended to the indifferent points of a multivariant system. [See Abstract No. 937 (1901).]
R. E. B.

2229. *Thermodynamics of Electrical Deposition.* **M. Frank.** (Elektrochem. Zeitschr. 8. pp. 86–91, July, 1901.)—A discussion of the thermal conditions in which electrolysis takes place.
J. E.-M.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2230. *The Science of Steam-raising.* **J. C. Parker.** (Eng. Club Phil., Proc. 18. pp. 147–155, July, 1901.)—Some of the physical conditions of steam generation are graphically represented by a diagram in which the vertical scale gives temperatures from 0° F. upwards, 2,500° F. being taken as the initial temperature of combustion. A curve is drawn from that point to represent a gradual fall in the temperature of the gases in their passage over the heating surface, to the point of exit at 600° F., and a horizontal line at 362° F. represents the boiler temperature due to a pressure of 143 lbs. per square inch, thus showing a difference of 238° between these two temperatures. The practice which aims at securing an equal temperature throughout a boiler necessarily prevents the gases being cooled below 362° F., but with another construction there may be different temperatures at different parts of the apparatus without detriment to it. Causing the feed-water to flow in a counter-current to the hot gases enables economy to be realised by lowering the temperature of the escaping gases which come into contact with feed-heater or economiser surfaces of a lower temperature than 362°. Superheat can also be added to the steam at the hot end of the diagram. Bringing the feed-water in at the hot end, or at the part of the boiler nearest the fire, causes a lowering of the temperature of combustion although the water is heated up more rapidly by this method. To secure the maximum transmission of heat from gases to water, they must flow in opposite directions, and evaporation must be completed in a single circuit, no recirculation of water once raised to the boiling-point being allowed, and a constant rapidity of flow being maintained.

"The diagram demonstrates that the functions of the economiser, the boiler and the superheater are but separated parts of a single progressive operation which can be more perfectly accomplished in one apparatus." The general principle is that of heat recuperation, first proposed by Stirling in 1816 ; applications were attempted by Belleville in 1856, Herreshoff in 1878, and Yarrow in 1898. Both Belleville and Herreshoff started with the counter-current principle and progressive evaporation, but failed through using a pump to maintain constant flow. Belleville abandoned this principle, and developed his boiler on that of supplying the water at the hot ends of the coils and adopting a gravity circulation. Yet this boiler, after twenty-two years of use and six years in the British Navy, has now been condemned by a British Parliamentary Committee, and at the opening of the twentieth century the steam-generating problem is still before us.

The principal conditions involved in the evolution of a satisfactory steam-generating apparatus are thus stated :—(1) The water and gases must flow in opposite directions to secure the maximum transmission of heat. (2) The flow must be constant and at maximum speed to obtain the highest efficiency of the surface and prevent overheating. (3) There must be no re-circulation of the water, evaporation must be secured in one circuit. (4) The steam must flow directly from the hottest part of the furnace to the steam reservoir without passing through the water. (5) The steam supply must be separated from the water so that priming, foaming, or lifting will be impossible. (6)

There must be sufficient steam and water room to prevent excessive fluctuations in pressure and water-level. (7) The internal surfaces must be kept clean automatically, and the external surface must be perfectly accessible. (8) There must be no fluctuations in the temperature of the metal, and the flow of feed-water on to hot surfaces must be made impossible. (9) There must be perfect flexibility to permit independent expansion of each part. (10) The apparatus must be simple, with fewest and best joints, and arranged to permit ready access to every part. (11) The apparatus must, with ordinary care, be absolutely reliable in operation, under adverse conditions. (12) The apparatus must be durable without frequent repairs, and with freedom from leaks. An "evaporation diagram," illustrating the action of the Parker steam generator (see Abstract No. 2235) is given to demonstrate the adherence of this boiler to these conditions. F. J. R.

2231. *Superheated Steam.* **G. A. Hutchinson.** (Mech. Eng. 7. pp. 810–812, June 8; 877–880, June 22; 8. pp. 61–64, July 13; 82–84, July 20; 131–133, July 27, 1901. Paper presented at the Milwaukee meeting (May, 1901) of the American Society of Mechanical Engineers.)—The use of better material in the construction of the superheater, of mineral oils having high ignition points for lubrication, and of asbestos or metallic packing, have now made the use of superheated steam practicable. Experience has, however, shown that with engines of ordinary design the temperature of superheated steam should not exceed 475° F. at the engine, as the lubrication difficulties are greatly increased beyond this point.

The equation for superheated steam is $pv = 93{\cdot}5T - 971p^{\frac{1}{4}}$, in which p is the absolute pressure in lbs. per square inch, v is the volume in cubic feet, and T is the absolute temperature in degrees F. With a feed-water temperature of 100° F., 1125·5 B.Th.U. are required per lb. to evaporate it at 150 lbs. pressure. A further addition of 112·6 B.Th.U. will superheat to 600°. So that 10 per cent. additional heat increases the volume of the steam 33⅓ per cent. Superheated steam being approximately in the condition of a perfect gas its specific heat is low: at constant pressure it is about 0·4805, while for air it is 0·2375. The superheat is soon lost by expansion. In engines, experience has shown that 125° to 175° of superheat are required to prevent condensation before cut-off. With low pressures an initial temperature of 650° is necessary in order theoretically to permit of superheat in the exhaust.

An example, by C. Jacobi, of the effect of different degrees of superheat in three tests of a 20-h.p. non-condensing engine is given, and a table of thermal efficiencies of simple and compound engines.

Tests of engines with superheated steam have also been made at Mulhausen, and by R. Doerfel (see Zeitschr. des Ver. Deut. Ingen. Dec. 9 and 16, 1899). In general they show an economy with compound as against triple-expansion engines and a saving in heat with the use of superheated steam. With old engines the superheating could best be effected with highly superheated steam introduced into the heating coils of the receiver and passing thence to the throttle valve. With superheating, no more condensing water need be used by the engines and the danger of admission of priming water into the cylinders is removed. The addition of a superheater is equivalent to an increase in boiler capacity. In using superheated steam in pipes designed for saturated steam there will be a less difference of pressure between the two ends of the main. With a speed of 100 feet per second there will be no more loss in pressure than with a speed of 60 feet for wet steam. The loss by radiation may be 1° F. for 2 feet of pipe, but has been reduced to 1° for 6 lineal

eet by using a good thick covering, a high steam speed and small radiating urface.

Any kind of superheater may either be fired independently or by neans of waste gases in boiler flues. The latter is more economical. When iring the boiler to raise steam the coils must be protected either by dampers or by flooding them with water. This latter has the disadvantage that mud or scale from the feed-water may be deposited in them and water hammer effects may also be experienced. Dampers are therefore preferable. To place the superheater in the chimney or in the main flue would involve too high a temperature of escaping gases for heat economy if the degree of superheat were to be useful. If placed too near the fire the coils would rapidly become overheated. A good superheater should have (1) security in operation, or a minimum danger of overheating, (2) economical use of heat applied, (3) no exposure of joints to the fire, (4) provision for free expansion, 5) disposition such that it may be cut out or repaired without interfering with the operations of the plant, (6) ease of application to existing plants. The tube elements may be arranged either in series or in parallel. In parallel, as in the Gehre superheater, the proportion of heating surface to quantity of steam is large, and the speed is not great. In series, as in the Schwoerer, the cross-sectional area must be larger, and the steam speed higher. High velocity is good if the volume of steam is not too large for the surface. Both parallel and counter-current flow are made use of sometimes, as in the Schmidt apparatus, combined in the same device.

The design and construction of the following superheaters are described, viz., the Hering, Walther, Steinmuller, Reisert, Meyer, Gehre, Simonis and Lanz, Buttner, Gohrig and Leuchs, Dürr, Göhring, Hildebrand, Fehrmann, Schwoerer, and Bohmer. They show the variety of ways in which superheating steam has been carried out. Details of working are, however, not given, except in the case of the Schmidt system. Of the Schmidt, Gehre, Walther, and Hering, hundreds of installations have been made, and over 2,000 of the Schwoerer. In fact, it is stated that nearly all the leading German boiler-makers now find it necessary to have some kind of a superheater to offer. This indicates the tendency of the times. Tests are given of a 3,000-h.p. four-cylinder vertical triple-expansion Sulzer engine, using steam which is described as highly superheated, moderately superheated, and saturated respectively. The steam consumption per h.p.-hour varied from 9·56 lbs. with high superheat to 11·75 lbs. with saturated steam. F. J. R.

2232. *Powdered Fuel for Boiler Furnaces.* (Eng. News, 45. pp. 452–453, June 20, 1901.)—Having tried the use of powdered fuel in firing a 250-h.p. Stirling (American) boiler, the Alpha Cement Company erected the plant described and illustrated in this article. It comprises a crusher, in which the raw coal (of bituminous slack or other cheap quality) is pulverised to the size of "rice" or "buckwheat" coal (about equal in grain to "pearls"); a drying furnace, which is used when the coal contains above 6½ per cent. of moisture; a grinding machine, an air separator, with the necessary elevators and storage bins, and a burner through which the dust fuel is admitted to the boiler furnace. The grinder and air separator are of novel design, the former using the crushing action of metal balls which are held loosely in pockets in the circumference of a rotating disc enclosed by a steel ring, and the latter having a fan ingeniously arranged to lift the fine dust from a central shoot to an external annular chamber, whilst the coarser particles fall down the central passage and return to the grinder. The finished dust is fed automatically by

a vertical pipe from the storage bin to the burner, which is a short horizontal pipe with a centrally placed nozzle for a jet of compressed air. The air and coal dust issue well mixed and burn very much like a stream of gas issuing at some speed from an orifice.

Results of tests are given. It is stated that the best combustion results were obtained when the coal was ground so fine that 90 per cent. would pass through a 150-mesh sieve. The chief drawback to the use of dust fuel is that on account of the risk of "spontaneous combustion" (so-called) on the one hand, and of its tendency to absorb moisture from the air on the other, it cannot be stored in a finely ground state with safety or efficiency. The object of the apparatus described is to provide means for powdering the coal as rapidly as it is wanted, and keeping only a trifling quantity stored.

In most cases the cost of pulverising amounts to from 10 to 25 cents [5d. to 1s.] per ton. The machinery for crushing, grinding, and separating 75 to 100 tons of coal per 24 hours requires about 25 h.p., or less than 1 per cent. of the power produced by the coal when burned under a boiler to raise steam. F. J. R.

2233. *Deposits in Steam Boilers.* **W. E. Ridenour.** (Frank. Inst., Journ. 152. pp. 113–118, Aug., 1901.)—This author deals with the chemical constitution and physical appearance of various salts existing in boiler deposits.

In estimating the quantity which accumulates in a boiler during a month's work, he bases his figures upon the following analysis of clear water from the Schuylkill, much used in Philadelphia :—

	Grains per U.S. gallon.
Organic and volatile	5·060
Calcium sulphate	3·560
Magnesium sulphate	0·602
Sodium chloride	1·167
Calcium carbonate	0·357
Solids	10·746

The scale-forming ingredients amount to 4·519 grains per gallon, and for 1,000 h.p., using 4 gallons evaporated per hour per h.p., the amount of accumulated solid is 1,040,000 (No. of gallons per month) × 4·519 = 4,699,760 grains or 671 pounds of sediment per month.

Some waters from wells average from 25 to 75 grains per gallon, and one specimen showed 83 grains per gallon, which of course give a much worse result than the above.

Calcium scales are generally hard and porcelain-like, though some are soft. They can generally be distinguished by their vitreous appearance. V. B. Lewes (Chem. News, 1899, 59–222) maintains that the sulphate is first deposited as a hydrate, $CaSO_4.H_2O$, which forms the anhydride $CaSO_4$, by the action of the heated plates. This author has always found the anhydride existing in deposits, of which the following is an example :—

	Per cent.
Moisture at 100° C.	0·23
Calcium sulphate	94·89
Magnesium hydrate	1·98
Silica	0·25
Organic and undetermined	2·65

Calcium carbonate deposits are usually soft, but acquire different degrees

of hardness by admixture with magnesia, calcium sulphate, or silica; when moderately pure, however, they are distinctly crystalline, this appearance being maintained in deposits containing only 51·73 per cent. of carbonate. In *Silicate scales* there is a combination of calcium oxide and silica, existing as calcium silicate, formed probably by boiling under pressure, the free silicic acid in the water reacting on the calcium carbonate. Several analyses of such deposits are given; the following, with that of the water from which it was found, being the most interesting:—

	Per cent.	Calcium silicate.
Calcium oxide	5·42	5·42
Silica	48·02	5·80
		11·22
Calcium sulphate	3·95	
Magnesium hydrate	3·58	
Iron oxide and alumina	27·08	
Organic and undetermined	11·95	

Analysis of the water—

	Grains per U.S. gallon
Calcium carbonate	1·311
Calcium sulphate	0·104
Magnesium carbonate	1·147
Sodium chloride	0·850
Silica	1·469
Organic and volatile	1·340
Solids	6·221

The *Magnesia deposits* have no distinguishing characteristics under the microscope, and are variously supposed to contain the oxide, hydrate, or carbonate. The author thinks the hydrate is the most usual, although he has found carbonate in some specimens. The carbonate is probably first deposited, and is changed by the heat to which it is exposed into the hydrate, or even the oxide. In fact the composition of deposits from the same water in different parts of a boiler is much affected by the temperatures at which they have been formed. F. J. R.

2234. *Boiler Trials on H.M.S. "Hyacinth" and "Minerva."* (Engineering, 72. pp. 283–285, Aug. 30, 1901.)—This is the Report of the President of the Boiler Committee on the performance of the Belleville boilers of the *Hyacinth* and the cylindrical boilers of the *Minerva* during a trial voyage to Gibraltar and back to Portsmouth. It is simply a record of the facts and incidents of the trial, but no opinion is added to the results.

The serious loss of water by leakage from the joints of the Belleville boilers and the choking of the fire tubes of the Scotch boilers by "bird-nesting," are the most prominent results manifested.

On the outward run the average h.p. of the *Hyacinth* was 7,047 for 103¼ hours, with a coal consumption of 1·97 lbs.—the distance run having been about 1,810 miles at an average speed of 17·6 knots. The *Minerva's* h.p. was 7,007 for 147 hours with a coal consumption of 2·06 lbs.: the distance run was about 2,640 miles at an average speed of 17·96 knots.

Tabular statements of results of trials carried out prior to the departure for Gibraltar, and of the results of the examination of the boilers of the *Hyacinth* on her return to Portsmouth, are given. F. J. R.

2235. *Parker Steam Boiler.* **H. G. Morris.** (Eng. Club Phil., Proc. 18. pp. 137–146, July, 1901.)—This is a straight tube boiler with reversed circulation, the water flowing downwards as it becomes heated, whilst the steam is taken off at the lowest point and is discharged directly into a dry steam chamber kept apart from the water. The gases flow upwards from the fire so that the hottest gases and water meet first. A 150-h.p. unit has 1,500 square feet of heating surface, and 31·5 square feet of grate surface. A single drum 42 inches diameter and 20 feet long is divided longitudinally by a diaphragm into upper and lower, or steam and water chambers, the lower being connected at the rear of the boiler to the "dished head," and at the front to a casting or steam space head in the upper chamber, an opening being provided into the lower one, 11 inches by 15 inches, controlled by a swinging non-return valve. There is also a small by-pass between the steam space of the lower or water chamber and the dry-steam chamber.

There are 96 horizontal tubes, 3 inches diameter and 18 feet long, arranged in vertical groups to form flattened spirals. There are 6 elements, each two tubes wide, composed of 16 tubes expanded into malleable iron junction boxes which form the bends of the spirals. The shape and arrangement of these boxes, with their hand holes, leaves four openings $1\frac{7}{8}$ inches square round each tube for brushing soot and dust. The upper ends of the elements are connected by short nipples to the vertical junction boxes and to a steel cross-box which is riveted to the under side of the drum. A brass disc is suspended in each of these vertical boxes in front of the nipple, and acts as a check valve against reversals of flow of water and steam. The lowest tube of each element is connected to a horizontal steel cross-box, or steam collector, which delivers all steam through two upcast pipes to the dry-steam chamber. The baffles of firebrick tiles, $1\frac{1}{2}$ inches by $4\frac{1}{2}$ inches by 9 inches, rest on the third and eighth rows of tubes.

The water is fed into the drum or cross-box, flows into the tubes and seeks its level in upcasts and drums—the working level being 2 to 12 inches below the diaphragm. When heat is applied, the water in the upcasts is driven out by steam, and the heavier column of water in the drum and tubes causes the flow downwards, the water being heated during its descent, and forming steam by the time the upcast is reached. A sudden withdrawal of steam from the steam-chamber causes the swinging valve to shut and prevent priming, the excess of pressure in the lower chamber serving to maintain the circulation.

This boiler can be fired from both ends. In a 500-h.p. double-ended unit the drum is 60 inches diameter and 20 feet long. The elements are single instead of double, with boxes vertical at both ends, giving 96 square feet of grate surface and 5,000 square feet of heating surface, on a floor space, including 17-inch walls, of 8 ft. 10 in. by 18 ft. 10 in. A vertical design can also be used if necessary, and a boiler of the two-drum horizontal design has been worked at Roach's shipyard at Chester, Pa., since April, 1900. F. J. R.

AUTOMOBOLISM.[1]

2236. *Alcohol as a Source of Motive Power.* (Locomotion Automobile, 8. p. 503, Aug. 8, 1901.)—This paper gives the results of experiments by Behrend at the Technical Institute of Hohenheim on the use of alcohol in a

[1] Electric Automobiles are described in the section dealing with electric traction.

Koerting engine of 6 h.p. nominal. Three mixtures of alcohol were employed, viz. :—(1) Alcohol denaturalised in the ordinary manner for commercial purposes. (2) Alcohol with benzine added to the extent of half the volume of the ordinary denaturalising agent. (3) The same mixture as (2) with an addition of 18 per cent. of benzine. The results were as follows :—

Mixture.	Quantity consumed per b.h.p.-hour.	Cost of spirit per b.h.p.-hour.
(1)	0·595 kg.	0·149 fr.
(2)	0·585 „	0·146 „
(3)	0·519 „	0·130 „

The cost of alcohol is taken as 25 fr. per hectolitre, and this is reduced by 0·837 fr. per hectolitre by the addition of benzine. The cost of running, when petrol is employed, is about 0·125 fr. per b.h.p.-hour. C. R. D'E.

2237. *Wheels and Tyres for Motor Trucks.* **W. L. Bodman.** (Horseless Age, 8. pp. 359–360, July 24, 1901.)—The author considers that it is impossible to obtain sufficient adhesion under many conditions of road surface, without the use of rubber tyres, on the driving wheels of a heavy lorry. The following points are mentioned as essential for the success of solid rubber tyres :—(*a*) Ample width of tread so that load may not exceed 650 lbs. per inch width. (*b*) Largest possible sectional area without liability to roll. (*c*) Perfect fixing to prevent creeping. (*d*) Smallest proportion of waste material for fixing tyre. A simple form of tyre-testing machine is illustrated, and also the method of construction of certain types of disc wheels and fixing rubber tyres thereto. C. R. D'E.

2238. *Shaffer Boiler and Engine.* (Horseless Age, 8. pp. 316–317, July 3, 1901.)—This boiler, which is intended for use in light steam cars, is constructed with two concentric cylindrical shells joined by end-plates. The water and steam spaces are between the shells, and the main flue passes up the central cylinder. Projecting from the water space into the central flue are water tubes of U form, placed vertically so that one leg enters the upper part of the water space, and the other leg enters the lower part. The steam is superheated in tubes which extend across the upper part of the central flue. Before escaping, the products of combustion are led down round the exterior of the outer shell. The shells are 10 inches and 14 inches diameter respectively and 14 inches high. The working pressure is 200 lbs. per square inch, and the boiler is rated at 4½ h.p. Its weight is stated to be about 60 lbs.

The engine is of the two-cylinder coupled vertical type, with a 2⅜-inch bore and a 3-inch stroke. All working parts are enclosed and plain bearings are used throughout. A special feature is the reversing-valve motion, in which both the slide valves are operated from one eccentric. C. R. D'E.

2239. *Riker Gasoline Carriage.* (Horseless Age, 8. pp. 310–311, July 3, 1901.)—This is a new American car, built very much on the lines of the French vehicles. The engine is mounted towards the front of the underframe and, together with the water-tank, is enclosed by a sheet-steel bonnet. It has two

vertical cylinders with pistons coupled to cranks at 180°. The cylinders are 4-inch bore, with 4-inch stroke ; and 9 b.h.p. is developed at 900 r.p.m. The carburettor is of the type in which a combined air and petrol control valve is lifted by the suction of the cylinders, and returned to its seatings by a spring. High-tension electric ignition is employed, with a separate coil for each cylinder. The cooling water circulation is maintained by a pump, and a radiator is mounted at the front of the bonnet. The power is transmitted from the crank-shaft through a special epicyclic gear, and a bevel drive, to a cross countershaft, and thence by chain gears to the road-wheels, which run on the ends of a fixed axle. By means of the epicyclic gear, three forward and one reverse speed are obtainable at a fixed speed of the engine. The wheel base is 5 ft. 6 in., and gauge 4 ft. 2 in., and the weight of the car is about 1,675 lbs. with tonneau body. A side elevation of the car and details of the carburettor and change speed gear are given. C. R. D'E.

2240. *Millot Carriage.* (Automotor Journal, 5. pp. 482–483, July, 1901.)—In this car a rectangular underframe carries near its front end a double-cylinder petrol engine. The power is transmitted from the engine to the change speed gear by means of pitch chains, and again from the change gear to the road-wheels by chain drives. The special feature of the design lies in the form of change speed gear employed. An aluminium gear-box encloses two parallel shafts, upon each of which is mounted an ordinary bevel wheel and pinion differential gear. The sleeves carrying the bevel wheels of the first differential gear project outside the gear-box, and upon each is mounted a sprocket pinion which may be caused to drive its sleeve through a roller clutch. Each sprocket and sleeve is driven independently from one end of the crank-shaft of the engine, which lies parallel with the gear-box shafts and at right angles to the length of the car. The roller-clutches permit of rotation of the differential sleeves in the direction of rotation of the engine only. On the exterior of the box of each differential gear is a toothed ring, and these are always in mesh for forward movement of the car. The second differential shaft is so mounted that an eccentric movement may be imparted to it, which brings its toothed ring either into or out of mesh with that of the first shaft. The movement which puts the toothed rings out of gear at the same time introduces a spur pinion which meshes with both and so gives the reverse motion. The three forward speeds given by the gear are obtained as follows : For the lowest speed the roller-clutch on the right-hand sprocket is thrown into gear, the bevel of the differential gear on this sleeve then rotates at a speed relative to the engine, which is determined by the ratio of the chain-drive. The other bevel of this gear tends to rotate backwards, being driven through the bevel pinions of the gear. The roller-clutch on its sleeve will, however, not permit of this, and the result is that the box of the differential gear with its toothed ring rotates at half the speed of the driven sleeve. The motion is transmitted to the other gear and its shaft by the spur-rings, which are now in mesh, and so to the road-wheels of the car. The intermediate speed is obtained by throwing the roller clutch of the left-hand sprocket into gear, the movement being then similar to those which give the slow speed. To obtain the highest speed both roller clutches are thrown in, then the box of the first gear is driven at a speed which is the sum of the speeds at which it would be driven when one or other clutch is engaged. The shaft which carries the second gear is connected by flexible couplings to the short shafts, which carry the sprocket pinions of the road-wheel chain-drives. This permits of the eccentric movement of the differential shaft, which is required for the reversing mechanism. C. R. D'E.

2241. *Sweet Engine.* (Locomotion Automobile, 8. pp. 474–475, July 25, 1901.)—This is a small, enclosed-type, compound steam engine with cylinders at right angles, the h.p. being horizontal and the l.p. vertical. The two pistons are coupled to a single crank, and ordinary flat slide-valves are employed. By means of a special form of cock, high-pressure steam may be admitted direct to the l.p. cylinder. A sectional elevation of the engine is given. C. R. D'E.

REFERENCES.

2242. *Superheated Steam.* **E. H. Foster.** (Eng. Record, 43. pp. 325–327, April 6, 1901. Paper read before the Amer. Soc. Mech. Eng. April 2, 1901.)—A short review dealing with the subject generally. H. R. C.

2243. *Balancing of Engines.* **W. E. Dalby.** (Engineering, 71. pp. 457–459, April 5; 490–492, April 12; and 521–523, April 19, 1901. Paper read before the Institution of Naval Architects.)—A full account of the balancing of the reciprocating parts of multiple crank engines, including the effect of obliquity of the connecting-rod. H. R. C.

2244. *Revealer for Studying Condensation in Steam-engine Cylinders.* **B. Donkin.** (Inst. Mech Engin., Proc. 4. pp. 509–532; Discussion, pp. 532–553, 1900.)—Description of an improved form of glass revealer and of a series of experiments with it. H. R. C.

2245. *Assistant Cylinder.* **D. Joy.** (Engineering, 71. p. 438 and pp. 442–444, April 5, 1901. Paper read before the Institution of Naval Architects.)—A short account of some improvements in Joy's "Steam Assistant Cylinder" for valve-gears. H. R. C.

2246. *Steam Heating Plant.* (Eng. Record, 44. pp. 86–88, July 27; 108–110, August 3; and 134–136, August 10, 1901.)—Very full particulars are given of the arrangements for heating and ventilating the buildings on Ellis Island, New York Harbour, and the steam-piping is described in detail. There is an electrical plant of 425 kw. capacity, the exhaust steam from which is used for heating. A. H. A.

2247. *Methods of Varying the Power of Petrol Motors.* **G. Lavergne.** (Locomotion Automobile, 8. pp. 529–530, Aug. 22, 1901.)—A review of the available methods of varying the power developed by a petrol motor, viz., by varying (1) the quantity of charge drawn in per stroke, (2) the point of ignition, (3) the pressure of compression. C. R. D'E.

2248. *The Motor Car and its Future.* **A. G. New.** (Feilden, 5. pp. 34–50, July, 1901.)

GENERAL ELECTRICAL ENGINEERING.

2249. *Economical Value of Electrical Energy, and the Electrical Production of Combustible Gas.* **O. Schmidt.** (Zeitschr. Elektrochem. 7. pp. 807–809, Aug. 1, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Berne, July 6, 1901.)—Comparing coal and electricity as sources of heat energy, the author arrives at the result that, on the average, only 30 per cent. of the energy is utilised in the former case: whereas in the latter this percentage is 90.

In the manufacture of water-gas he recommends electrical heating, instead of the usual process of supplying the necessary heat by blowing in air and burning up part of the coke. In this way he calculates that a saving of over 33 per cent. of the coke can be effected. The conclusion is arrived at that it would be cheaper to supply water-gas than electricity, now that the necessity for a luminous flame has very largely ceased to exist, owing to the widespread use of Welsbach burners. The author is of opinion that it would be easy to adapt carbide furnaces to the manufacture of water-gas. Finally, he considers the possibility of dispensing with coal entirely, and supplying the gas-works with pure hydrogen obtained by electrolysis.

[The calculations are founded on the economical conditions existing in Switzerland.] F. G. D.

2250. *Measurement of Power taken by Three-phase Motors.* **G. Stern.** (Elektrotechn. Zeitschr. 22. pp. 539–542. July 4, 1901.)—In measuring the power supplied to three-phase induction motors, it is generally assumed that the three phases take equal currents, which exhibit equal phase differences. This assumption leads, in the case of three-phase supply meters intended for motor circuits, to forms of construction which are simpler than those used in connection with unbalanced three-phase circuits. The author points out that with a mixed lighting and power load the p.d.'s across the three branches of the network are in general unequal, and hence the currents taken by the three circuits of a motor will also be unequal, and will have phase differences other than 120°. He calculates the maximum possible error of measurement, with meters of simplified construction based on the assumption of equality of the three p.d.'s (assuming the differences of p.d. to be so small that no appreciable change of apparent impedance results), and finds that this error expressed as a percentage always exceeds the percentage difference between the p.d.'s. A series of careful measurements is given which confirms this result, and the author concludes that the use of approximate methods of power-measurement (based on assumption of equality of p.d.) should be abandoned in the case of three-phase supply meters and wattmeters. A. H.

2251. *Influence of Temperature on Accumulator Capacity.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 19. pp. 353–356, July 21, and pp. 362–364, July 28, 1901.)—Experiments were made with cells in which the temperature of the acid was raised to 60° C. The general effect was to increase the capacity. A cell, for example, which had at 15° C. a capacity of 36·9 ampere-hours, when raised to 60° C. had its capacity increased to 55 ampere-hours. The increase of conductivity and diffusivity of the electrolyte accounts for the greater energy efficiency which was also noted. W. W. H. G.

2252. *The Edison Accumulator.* **F. Peters.** (Centralblatt Accumulatoren, . pp. 185–188, July 1, 1901.)—The new invention of Edison is described, and he details furnished by A. E. Kennelly [see Abstract No. 1775 (1901)] to the American Institute of Electrical Engineers are discussed. He calculates that Edison's cell requires 9 sq. dm. of electrode surface for each kg. of cell, which is at least twice as great as in the case of the lead automobile type of cell. Further, for a given pressure, the mean voltage being 1·1, about double he number of cells will be necessary. He considers the positive electrodes .re much too compact, and makes other adverse criticisms. W. W. H. G.

2253. *Nickel Oxide Alkaline Cells.* **A. L. Marsh.** (Elect. World and Engineer, 38. p. 136, July 27, 1901.)—Particulars are given of the various oxides of nickel and their method of preparation. The author is of opinion that nickel peroxide, NiO_2, is the real depolarising agent in Edison's Iron-Nickel oxide accumulator, being electrolytically reduced on discharge to nickel sesquioxide, Ni_2O_3. E. J. W.

2254. *Marino Accumulator.* **W. Hibbert.** (Elect. Rev. 49. pp. 131–132, uly 26, 1901.)—This cell is built up of horizontal lead electrodes, containing he usual active materials, and kept apart by porous separators. Its chief eature is the use of dilute phosphoric acid as the electrolyte, and the chief nterest of the article consists in the curves and particulars given of the conductivity of phosphoric acid solutions of various strengths, and of the e.m.f.'s they furnish with lead-lead peroxide electrodes. E. J. W.

2255. *Indiarubber Strip.* **H. L. Terry.** (Electrician, 47. pp. 662–663, Aug. 23, 1901.)—A strip is either "cut" or "spread," the later being cheaper. The raw material and its washing and drying are the same in both cases. For *cut sheet*, the dry rubber is compressed between steel rollers, and passed through a masticator similar to Hancock's original machine. The block of rubber is then subjected to hydraulic pressure, frozen hard by chemical means, and cut into sheets by a special machine. For *spread sheet*, the dry rubber is dissolved in coal-tar naphtha, spread on a length of cloth, the naphtha evaporated by passage over a steam chest, and the spreading repeated until the required thickness is obtained. The author points out that the failure of pure rubber to keep sulphur from the copper of cables has led in some cases to the substitution of cellulose. M. O G.

2256. *Variable-Tariff Meters.* **G. Goisot.** (Écl. Électr. 28. pp. 27–30, July 6, 1901.)—This article gives descriptions of a number of the above meters. The first is that of G. Rasch, of Carlsruhe, in which the shunt-coils of the meters are put in series, during the time of low tariff, *i.e.*, early in the day and late at night, with a resistance at the central station, a special conductor being provided for this purpose.

An early form of Aron meter is also described, in which the current through the shunt or pendulum coil is supplied, during the time of high tariff, by a special generator. At the time of low tariff, this current is raised until an automatic cut-out is operated, which puts the shunt-coil across the mains, at the same time disconnecting it from the special generator. The two-tariff clockwork Aron meter is then referred to [see Abstract No. 1572 (1901)].

In the Union Elektrizitäts Gesellschaft meter (German patent No. 99021), there are two counting trains, one of which is always in gear with the motor, whilst the other is thrown into and out of gear by a clutch controlled by an

electromagnet, the circuit of which is made and broken by a switch driven by a clock, so as to register at the time for which there is a special tariff.

In the Loubery, François and Kunkelmann meter, which is a motor-meter, a master-clock at the central station completes circuits including an electromagnet in each meter. The pole-pieces of this electromagnet are arranged on opposite sides of the damping disc of the meter, so that the rate of the meter is altered when the electromagnet is energised. Or the master-clock can act through a relay to complete a local circuit. Other arrangements are also suggested. C. K. F.

2257. *Electric Elevator in the Washington Monument.* **C. M. Lewis.** (Elect. World and Engineer, 38. pp. 176–179, Aug. 3, 1901.)—An Otis elevator worked by a steam engine formerly conveyed passengers to the top of the monument, which is 555 feet high. The original elevator car, with safety devices, &c., weighed 6,500 lbs., and when carrying a normal load of 6,000 lbs. the net load on the hoisting drum was 12,500 lbs. By substituting electric machinery and a counterweight system the weight of the car, safety devices, &c., has been reduced to 5,670 lbs., and as the weight of the drum counterbalance is 8,040 lbs. that leaves a net overbalance on the hoisting drum of 2,370 lbs. when the car is empty. With the maximum load of 6,000 lbs. in the car the net load on the hoisting drum to be lifted by the winding mechanism is now 3,630 lbs. This at 100 feet p.m. is equivalent to 11 h.p. as compared with the 18·9 h.p. required for gravity work in the old car. The new system can therefore lift the same live load at double the car speed with 58 per cent. of the energy formerly required, and leave sufficient power to light the monument and grounds with electric light, without increasing the number of boilers or of employés at the monument. The power-house was enlarged and a duplex compound steam engine of the tandem marine type, with a 240-volt continuous current direct coupled generator, was installed in it, copper cables being run to the switchboards for the elevator motor and the electric lights at the monument. The electric generator has a capacity of 50 kw. at 275 r.p.m. The cylinder dimensions of the engine are 9½ and 15 by 11, and the guaranteed consumption of steam is 27 lbs. per i.h.p.-hour. There are complete fittings to the switchboards, and in this paper photographs of the machinery are reproduced, with minute descriptions.

The principal novelty consists in the "safety" apparatus of the car, which works on a smooth web of steel T-rails or vertical guides. The gripping mechanism is controlled by wedges at both sides of the car, which force open the jaws of gripping levers, these wedges being drawn together by means of a spring acted upon by a right- and left-handed screw safety spindle, which begins to revolve as soon as the speed of the car exceeds the normal rate. The safety mechanism can be operated from the car and can also be made to stop the car whilst ascending or descending.

The guaranteed efficiency of the whole elevator system was 40 per cent. at maximum load, and an efficiency of 41·09 per cent. from the electrical energy delivered to the controller was obtained on test. F. J. R.

2258. *Becker's Electric Clock.* (Engineering, 72. pp. 117–118, July 26, 1901.)—This is a secondary clock adapted to be operated by an impulse every half-minute from a master-clock; there is a ratchet-wheel on the minute-hand arbor, this ratchet-wheel being operated by a pawl on a rocking-lever moving between fixed stops and controlled by an electromagnet. The feature of the mechanism consists in an "inertia stop," which is rigidly mounted on the

rocking-lever and acts in conjunction with a retaining-pawl, so as to lock the ratchet-wheel when the rocking-lever is displaced by the electromagnet. For this purpose, the inertia-stop, as it moves out of engagement with and thereby releases the ratchet-wheel, moves over the retaining-pawl and holds it closely in engagement with the ratchet-wheel. By this means the effects of wind-pressure on the hands, &c., during the displacement of the rocking-lever are rendered harmless, and the hands can only be moved by a complete back and forward stroke of the rocking-lever. The action of gravity on the rocking-lever is assisted by a spring, so as to ensure that there shall always be sufficient energy available, on de-energisation of the electromagnet, to move the hands. C. K. F.

REFERENCES.

2259. *Electric Cranes.* **W. Müller.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 691–694, May 18, 1901.)—A description, with drawings, of two cranes lifting 25 tons and 50 tons respectively, and driven by direct current at 500 volts. W. H. E.

2260. *Calculating the Capacity of a Battery for a given Output.* **K. Norden.** (Elect. World and Engineer, 37. pp. 396–397, March 9, 1901.)—The author gives a graphical method of calculation based on a known or predetermined output, or discharge curve, taking into account the variation of capacity with rate of discharge. C. K. F.

2261. *Cahill Electric Typewriter.* **B. C. Washington, Jr.** (Elect. World and Engineer, 37. pp. 763–764, May 11, 1901.)—Description of a typewriter with electrical action. C. K. F.

2262. *Electric Coal-tip at Rotterdam.* (Zeitschr. Vereines Deutsch. Ing. 45. pp. 793–805, June 8, and 835–845, June 15, 1901.) —A very complete description of a coal-tip, which has been constructed by Nagel and Kaemp, and erected on the harbour at Rotterdam for the purpose of loading and unloading coal. The article contains more than one hundred drawings, showing details of construction, &c. W. H. S.

2263. *Electricity in the Ship-yard.* **J. H. Biles.** (Eng. Mag. 21. pp. 525–547, July, 1901.)—An article containing illustrations of some electrically-driven machinery.

2264. *Electrically-driven Machine Tools.* **C. B. Nixon.** (Inst. Elect. Engin., Journ. 30. pp. 1200–1207, Aug., 1901.)—The author describes two of the power-stations of the Lancashire and Yorkshire Railway, viz., those at Newton Heath and at Oldham Road, Manchester. He also gives figures showing the results of working, and concludes by giving a list showing the power taken by machinery of different kinds, installed in the works under notice.

GENERATORS, MOTORS, AND TRANSFORMERS.

2265. *Maximum Efficiency of Dynamos.* **L. Finzi.** (Elektrotechn. Zeitschr. 22. pp. 634–635, Aug. 8, 1901.)—Assuming that the total losses occurring in a loaded machine consist of two parts, one of which is a constant (no-load losses), while the other increases with the square of the current—an assumption which is justified by experiment—the author shows that maximum efficiency is reached with that value of the current for which the two kinds of losses become equal. A. H.

2266. *Rise of Temperature in Field-coils of Dynamos.* **E. Brown.** (Inst. Elect. Engin., Journ. 30. pp. 1159–1199, Aug., 1901.)—In this paper the author describes a series of experiments which he carried out in order to ascertain the distribution of temperature in the field-coils of dynamos under various conditions. The experiments were made with a Siemens dynamo, of which the output was 55 amperes at 135 volts at a speed of 1,250 r.p.m. This was run as a motor, with a current of $2\frac{1}{2}$ amperes maintained constant through the experimental field-coil, while the armature ran either light or loaded, and at different speeds. The temperature was measured in each case, after five hours steady run, by measuring the increase of resistance of pilot wires of known temperature coefficient and resistance, which were fixed in position during the winding of the coil at three different depths, and in different positions with respect to the longitudinal axis of the coil. Full details of the construction of the experimental coil are given, and also a large number of curves exhibiting the results obtained. These show—(1) The effect of increase of armature speed on the rise of temperature along the vertical layers of the winding, under different conditions of armature load. (2) The effect of increase of armature speed on the rise of temperature through the horizontal depth of winding at points half-way along the axis of the coil, under different conditions of armature load. (3) The effect of increase of armature-current on the rise of temperature along the three vertical layers of the winding, under the different armature speeds. The experiments were all made in duplicate, with the experimental coil first on one limb of the magnet and then on the other, as the fanning action of the armature was different in the two cases. Some interesting results are arrived at, the high-temperature gradients in the winding under certain conditions being specially noticeable. Thus, under normal full-load conditions, the surface rise of temperature observed was 29° C., the average rise in the coil 50° C., and the maximum 60° C. Under certain conditions an increase of current in the armature may actually diminish the temperature of the field-coils. No satisfactory explanation is offered of this curious phenomenon, though it is believed to be connected with convection currents of air produced by the rotation of the armature (as distinguished from the ordinary fanning action).

Amongst the practical conclusions to which his experiments point, the author refers to the desirability of making the end surfaces of the field-coils as thermally conducting as possible, and suggests an increase also in the thermal conductivity of the materials interposed between the winding and the cores. In this connection the advantage of a good fit between the

bobbin and the core is emphasised. The suggestion is also made that the field-winding should be made shallower in the middle than at the ends, in view of the much greater rise of temperature noticed in the middle section of the winding. B. P. S.

2267. *Compounding Alternators.* **M. T. Gentile.** (Elettricità, Milan, 20. pp. 51–53, Jan. 26; 195–201, March 30; 340–343, June 1, and pp. 358–359, June 8, 1901.)—The author treats the cases where alternators are excited partially by a continuous current and partially by a rectified current obtained from the secondary of a transformer, the primary of which is in series with the main circuit; also when they are excited by the current from a rotary converter run off a series transformer. In each of these methods compounding can be realised only when the reactance of the armature is negligible. The author then considers Leblanc's method of exciting alternators by means of a synchronous converter [Abstracts Nos. 620 and 908 (1899)], and gives the results of some tests on a slightly over-compounded machine. G. H. B.

2268. *Theory of Short-circuited Alternator.* **F. Horschitz.** (Elektrotechn. Zeitschr. 22. pp. 537–539, July 4, 1901.)—The author assumes sine waves of e.m.f. and current, and supposes that the space-distribution of the magnetic flux due to the field ampere-turns also follows the sine law. Under these circumstances, each point on the armature is subject to the action of two magneto-motive forces, which vary according to the sine law. One of these, that due to the exciting current, has a maximum value equal to the product of the exciting current into the field-turns; while the other, that due to the short-circuit armature current, is equal to the product of the armature turns into the *maximum value* of the armature current. By compounding these ampere-turns, the resultant ampere-turns are obtained. The short-circuit e.m.f. is proportional to the resultant ampere-turns, and must be sufficient to balance both the resistance and the inductance drop in the armature. The author determines the value of the resistance and inductance by obtaining a curve which connects the short-circuit current with the frequency for a given value of the exciting current. Experiments carried out by the author are in almost perfect accord with his theory. A. H.

2269. *Rotating Field of Two-pole Three-phase Winding.* **O. Bergmann.** (Zeitschr. Elektrotechn., Wien, 19. pp. 356–357, July 21, 1901.)—The author investigates the variations in the intensity and direction of the field produced by a three-phase winding, the axes of whose coils make angles of 120° with each other, the algebraical sum of the three currents being zero, but the currents being in general unequal, and their phase differences having assigned values; further, the permeability of the magnetic circuit is assumed to be constant. It is found that in the general case both the intensity and the angular velocity of the resultant field vary, becoming constant in the special case of phase differences of 120° and equal currents. The extremity of the resultant field-vector is found to trace out an ellipse. A. H.

2270. *Predetermination of Short-circuit Current in Three-phase Generators.* **R. Bauch.** (Zeitschr. Elektrotechn., Wien, 19. pp. 373–380, Aug. 4, 1901.)—In calculating the armature ampere-turns of a three-phase generator, it has been usual to take $1{\cdot}5\sqrt{2}Si$ as the ampere-turns, S standing for the numbers

of conductors per pole and phase, and i for the r.m.s. value of the current in one phase. The author shows that the factor 1·5 is too small, and that a better agreement with experimentally determined values is obtained by taking the factor $\sqrt{3}$. A. H.

2271. *Calculation of Ampere-turns for Teeth of Armature.* **E. Dick.** (Elektrotechn. Zeitschr. 22. pp. 598–601, July 25, 1901.)—The author first considers the simple case in which the tooth is of uniform thickness, and, treating the iron of the tooth on the one hand, and the slot and air spaces between core discs on the other, as two parallel paths open to the magnetic flux, calculates the joint reluctance of a tooth and slot. Taking next the case of a tapering tooth, he divides up the tooth and slot into a series of parallel layers normal to the flux by cylindrical surfaces co-axial with the armature. Each of these layers—provided its radial depth is not excessive—may be treated as a shallow tooth and slot with parallel sides, and so the exciting ampere-turns for the teeth may be found by a summation of the ampere-turns for the consecutive layers. A. H.

2272. *Determining Hysteresis and Eddy Current Losses in Dynamos.* **E. Strymeersch.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 164–171, July 6, 1901.)—The methods of Housman and Swinburne for determining the hysteresis and eddy current losses in dynamos and motors are described, and the necessary precautions are pointed out. The dynamo is run as a motor at various speeds, the excitation being kept constant, the highest speed corresponding to the e.m.f developed in the dynamo at the load at which the losses are to be measured. Experiment shows that the power lost by eddy currents is proportional to the square of the speed (n), whilst hysteresis and frictional losses are directly proportional to the speed. If E be the applied p.d. and C the current, then the total losses (EC) may be written—

$$EC = kn^2 + k'n.$$

Since the excitation is constant, $E = an$; hence—

$$C = \frac{k'}{a} + \frac{kE}{a^2}.$$

If we plot out C and E for different values of E we get a straight line. An experiment on a shunt motor is described illustrating the accuracy of this method. The armature and shunt resistances when warm measured 0·074 and 57·1 ohms respectively. When running on its normal load it took 45 amperes at 100 volts. Hence the back e.m.f.—

$$= 100 - \left(45 - \frac{100}{57{\cdot}1}\right)0{\cdot}074$$

$$= 96{\cdot}8 \text{ volts.}$$

The current at this back e.m.f. was found to be 4·9 amperes. The total losses are therefore $96{\cdot}8 \times 4{\cdot}9 = 475$ watts. Drawing the diagram of current and volts and finding the areas of the triangle and rectangle respectively in the usual manner, it is found that the losses by hysteresis and friction are 194 watts, and by eddy currents 281 watts. A. R.

2273. *Extensions of Swinburne's Method of Testing Dynamos and Motors.* **Brunhes.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 72–93, July 6, 1901.)—Swinburne's method of testing dynamos and motors is to run them at no load

nder the same magnetic conditions as at full load, and hence to find the osses due to friction, hysteresis and eddy currents. The chief cause of error rises from the difference between the mechanical friction in the two cases. In the case of rotary converters and dynamotors the error due to this difference is negligible. In the formula for calculating the heating in the armature of a rotary converter, $\cos\phi$, the power factor of the alternating current circuit, enters. If we calculate this heating on the assumption that $\cos\phi$ is unity, we get an approximate value of the efficiency (η). Now—

$$\eta VC = nEI\cos\phi$$

where V,C and E,I are the direct and alternating volts and amperes respectively and n is the number of phases. Hence we find an approximate value for $\cos\phi$. Substituting this value of $\cos\phi$ in the formula for the heating the value of η can be found to a second approximation, which is generally sufficiently accurate for practical purposes. When an alternating current transformer is on a non-inductive load and there is no leakage—

$$E_2 = V_2 + R_2I_2.$$

Hence if we apply by a rotary transformer such a voltage (V_1) to the primary that the secondary volts are E_2, then we can find what the loss in the core of the loaded transformer is, and so find its efficiency. To find the ratio (n) of the back e.m.f. in the primary to the e.m.f. producing the current in the secondary, the following approximate formula is given :—

$$n = \sqrt{\frac{k}{k'}},$$

where k is the ratio of primary volts (V_1) to E_2 and k' is the ratio of the secondary volts required to produce a primary voltage E_1, where E_1 is the back e.m.f. in the primary when the open circuit secondary volts are E_2. In general—

$$k = n\left(1 + \frac{R_1I_1}{V_1}\cos\phi_1\right) = \frac{V_1}{E_2}.$$

Hence $\cos\phi_1$ can be found, and the efficiency of the transformer calculated without using a wattmeter. If there is no magnetic leakage $n = \frac{n_1}{n_2}$, where n_1 and n_2 are the number of primary and secondary turns respectively. The author says that rotary converters can be usefully employed for measuring the power given to transformers, synchronous or asynchronous motors, &c., or for testing alternators. A. R.

2274. *Artificial Loading of Alternators.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 22. pp. 682–684, Aug. 22. 1901.)—In order to effect a saving of power in the testing of large alternators, it is convenient to run them at full excitation, so as to obtain the full iron losses, and to produce heating of the copper by sending the full-load current through the armature coils from an independent continuous-current machine of small output. This must, of course, be effected in such a manner as to prevent the alternating e.m.f. from sending a current through the auxiliary continuous-current machine. In the case of a three-phase generator with a Δ-coupling of the coils, the armature circuit may be opened at any convenient point, and the dynamo introduced into the circuit at that point. If the coupling of the coils is a star coupling, it may be temporarily converted into a Δ-coupling for the purposes of the test ; or a three-phase transformer may be connected to the alternator, and the dynamo

terminals joined to the neutral points of the alternator and transformer (a continuous current being at the same time sent round the secondary of the transformer, arranged Δ fashion). Similar arrangements may be adopted in testing large transformers. If two such transformers are available, the primaries and secondaries are coupled star fashion, the free ends of the secondaries of one transformer being connected to those of the other (the e.m.f.'s being in opposition); two sources of continuous e.m.f. are then used, one being connected between the neutral points of the primaries, the other between those of the secondaries. A. H.

2275. *Interpolar Induction and Distribution of Copper in the Armature of a Siemens Alternator.* **E. Wilson** and **W. Marden.** (Electrician, 47. pp. 633–635, Aug. 16, and pp. 679–681, Aug. 23, 1901.)—Experiments to determine the distribution of induction between the pole-pieces of a Siemens 12-pole alternator are described. The armature was taken out of the machine, and a flat piece of wood, in which exploring coils of various shapes were embedded, was placed opposite a pole-piece. The current in the exciting coils being reversed, the throws on a ballistic galvanometer, put successively in series with the exploring coils, enabled the induction density of the field to be calculated and mapped out. The air space was then altered from $\frac{1}{2}$ inch to $1\frac{1}{8}$ inch, and the magnetic field again mapped out. From these diagrams the e.m.f.'s generated by loops of wire embracing given fractions of the pitch of the magnet-poles is found, and the e.m.f. waves for the two cases are constructed. The innermost turns of the armature were found to contribute an e.m.f. with two maxima per half period. The figures obtained by calculation agree with those obtained when the machine is running. The leakage coefficients found show the effect of varying the air-gap. The most economical distribution of copper in the armature for a given air space and distribution of induction is considered. The authors do not feel justified in drawing any general conclusions, but in the particular magnetic circuit experimented on, the armature loss is a minimum when the ratio of the width of the armature winding to the pitch is one-third. A. R.

2276. *Large Continuous-Current Generators.* **H. M. Hobart.** (Elektrotechn. Zeitschr. 22. pp. 650–653, Aug. 15, 1901.)—The author compares English and American specifications for large generators with Continental ones. Both require a fixed position of the brushes for all conditions of load, and the differences in other respects are set forth in the following table:—

	English and American.	Continental.
Overload capacity	50 per cent. during two hours without excessive sparking or heating.	25 per cent. during half-hour without excessive sparking or heating.
Maximum temperature rise measured thermometrically	35° C.	50° C.
Temporary overload ...	100 per cent. without excessive sparking or heating.	50 per cent. without excessive sparking or heating.

The author states that a convenient estimate of the sparking tendency is given by the product of the square root of the armature ampere-turns per pole into the reactance voltage. He advocates the use of relatively wide, shallow slots, and of several commutator segments per slot. A temperature rise of not

more than 0·7 to 1° C. per watt per square decimeter of the cylindrical surface of the armature is easily obtained with well-ventilated armatures. On account of the uncertainty regarding the correction for the fringe of the field, the author assumes the cross-section of the air-gap to be equal to the polar area, and finds that, for practical purposes, in calculating the ampere-turns, this assumption is sufficient. He advocates an air-gap induction of about 8,700. A tabular comparison of three 1,000-kw. generators is given, one of these being by Siemens and Halske, another by the General Electric Company, and a third designed by the author. A. H.

2277. *No-load Losses in Induction Motors.* **G. Benischke.** (Elektrotechn. Zeitschr. 22. pp. 698–700, Aug. 29, 1901.)—The method employed by the author for separating the various losses at no load depends on the fact that for small loads the slip is proportional to the load. The slip may be measured with great accuracy, even at no load, by the author's stroboscopic method [see Abstract No. 1116 (1899)]. If the power-slip line (power as abscissa, slip as ordinate) be produced backwards, its intersection with the axis of power will give the true power lost by friction. On subtracting this from the wattmeter reading at no load we get the iron loss. The author draws attention to the fact that the observed iron loss considerably exceeds the calculated one, and that the commonly made assumption as to the iron loss in the rotor being negligible when the rotor is running is not borne out by experiment. According to the author's results the iron loss is almost the same in a standing as in a running rotor. This he attributes to high-frequency magnetic fluctuations in the rotor teeth and to the fact that the field is a pulsating as well as a rotating one. He further discusses the discrepancy between the calculated and observed values for the iron loss, and attributes it to the want of uniformity in the flux distribution, and to the magnetic hardening of the core discs under the mechanical treatment through which they pass in the process of construction. A. H.

2278. *Theory of Rotary Field Motors.* **Meller.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 93–137, July 6, 1901.)—A rotary magnetic field similar to that produced by polyphase currents can be obtained by rotating a coil carrying a constant continuous current. From this are deduced all the ordinary formulæ for the starting torque, lag, &c., of asynchronous motors. Asynchronous motors at constant current are first considered, and the effects of armature reaction are clearly explained. A formula is found for the torque, taking magnetic leakage into account, when the motor is supplied at constant voltage. The resultant magnetic flux is then constant, but at constant current it is the total magnetic flux that is constant The use of an asynchronous motor as a frequency converter is fully explained. A. R.

2279. *Self-starting Single-phase Motor without Brushes.* **J. Fischer-Hinnen.** (Elect. World and Engineer, 37. pp. 1066–1067, June 22, 1901.)—This motor consists of two stators arranged coaxially, with the poles set at an angle of 45° with each other, if the machine is bipolar, or generally at an angle of $\frac{90^\circ}{p}$ (p = number of poles). A long armature (which may be of the ordinary short-circuited type, or a wound rotor with slip-rings) rotates within the two stators. The machine is started by switching the current on to one stator only; the current induced thereby in the rotor winding produces in its turn a magnetic field in the other stator, which is in such a direction as to

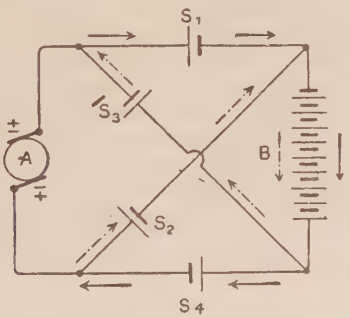
produce a turning moment in the rotor conductors when in this field. The motor then runs up to speed, and when synchronism is reached, the other stator is switched on, and the machine continues to run as an ordinary induction motor. The author points out that the direction of rotation simply depends on which stator is switched on first. It is suggested that the principle could be applied to arc lamps and wattmeter mechanism. The author also shows that the self-starting effect can be obtained by closing the secondary stator field through a short-circuit across two points on a diameter inclined at an angle of $\frac{90^\circ}{p}$ to the magnetic axis of the primary stator field. In either case the slots should be entirely closed. B. P. S.

2280. *Constant Current Transformers.* **R. B. Owens.** (Elect. World and Engineer, 38. pp. 21–22, July 6, 1901. Abstract of a paper read at the Ottawa Convention of the Canadian Electrical Association.)—For street arc-lighting it is advantageous to have a transformer which will give a constant secondary current over a wide range of loads. A test of a small constant-current transformer of the repulsion type is first described. The regulation is excellent, the current remaining constant over a wide range, but the power factor of the whole transformer is low, having a maximum of about 0·8 when the frequency is 60, and a still lower maximum for higher frequencies. The author next describes a method, due originally to Leblanc, of obtaining constant currents by means of choking coils and condensers. A choking coil and a condenser are put in series, and the condenser is shunted by another choking coil and the variable load. When a constant p.d. was applied at the terminals of the two in series, it was found that the current in the circuit shunting the condenser was very approximately constant, this effect being due to resonance. The power factor of the combination was very high, being about 0·99 over the whole range. The author thinks this method might be usefully developed commercially. A. R.

2281. *Pollak's Electrolytic Rectifier.* **J. Blondin.** (Soc. Int. Élect., Bull. 1. pp. 323–338, July, 1901.)—The author prefaces his paper by a historical sketch, from the first discovery by Buff in 1857 of the electrolytic valve action of an aluminium electrode; its rediscovery by Ducretet; the discovery of analogous phenomena in the case of other metal electrodes, of the electric arc between carbon and metal, and of Crookes tubes; by Nichols, Eichberg and Kallir, and Villari respectively. He then discusses the contributions made in succession by Beetz, Streintz, Hutin and Leblanc, Pollak (whose first patent was taken out in 1895), Graetz, Wilson, Kaller, Norden and Nodon, bringing the development down to Pollak's recent notable advances. The latter, by the substitution of potassium phosphate as the electrolyte, in place of the sulphuric acid previously used, succeeded in raising the maximum p.d. possible between the electrodes, without breaking down the unilateral insulation, from 20 to 140 volts. He then further increased this to 200 volts, by a process to which he gives the name of *formation*. The aluminium plate, about 1 mm. thick, is first immersed in caustic potash solution until the thickness is reduced to about 0·75 mm., all traces of grease and adhering metallic particles being thereby removed. It is then made the anode, with a lead kathode, in a slightly acid solution of potassium phosphate; and the p.d. between the electrodes is gradually increased until it amounts to 200 volts. To prevent destruction of the aluminium plates they must be

entirely immersed in the electrolyte, the aluminium must be protected by rubber cushions from any contact other than with the rubber and the electrolyte, and the temperature must not be allowed to rise above 40° C.

In the practical use of these rectifiers, *e.g.*, for charging accumulators from alternate current supply leads, one lead may be connected to the neutral point of the battery while the other is divided into two branches, one being connected to each pole, and each containing a rectifier, the aluminium plate of one being connected to the positive pole of the battery, and the lead plate of the other to the negative pole. In this arrangement, however, only half the battery is being charged at any one moment, and to obviate this Pollak employs 4 rectifiers, S, arranged as shown below, the thick line in the diagram of the rectifier representing the aluminium plate.



With a load such as accumulators or motors, in which there is a counter-e.m.f., only the crests of the waves are utilised : this will also hold good for arc lamps [on account of the unilateral conductivity of the arc] which the author includes among loads giving rise to a counter-e.m.f. The current will therefore be unidirectional, but interrupted. With a load such as incandescent lamps, where there is no counter-e.m.f. [nor unilateral conductivity] the current will be unidirectional and undulatory. In the case of polyphase currents, in which two rectifiers are required for each phase, the current will become more nearly a steady one the greater the number of phases. Illustrations are given of the rectifier as now made by Pollak. By making the depth of electrolyte about three times that of the plates, he has been able to run for four hours without raising the temperature above the limit of 40°. The rectifiers may be kept cool for longer runs by means of a system of tubes with water circulation. Hitherto he has only been able to make them of small sizes owing to the difficulty of preventing buckling of the aluminium plates.

The plates must be removed from the electrolyte when not in use, as otherwise they slowly dissolve. When this precaution is taken they can be run from 500 to 800 hours. It is not found possible to run two rectifiers in series, as the interactions very soon break down the unilateral insulation in one or other of them.

Pollak states that he has obtained an efficiency of from 75 to 80 per cent. with a current density of 1 ampere per square decimetre of aluminium, a voltage of 110 and $\sim$ 42. The efficiency is found to increase with the p.d. up to the possible limit, and diminishes with increase of frequency.

The rectifiers have been successfully employed with arc lamps, accumulators, and shunt-wound motors, no abnormal heating being observed in the latter case due to the variation of the current. The author ascribes this to

the variation being minimised by the fact that the motor itself maintains an exciting current during the intervals of no current from the source of supply. Various practical applications are suggested in the paper. G. W. DE T.

2282. *Electrolytic Rectifiers.* **J. A. Montpellier.** (Électricien, 22. pp. 17–18, July 13, 1901.)—In order to render alternating currents available for direct-current applications, the current must be commuted (1) by commutators, rectifiers, or converters, or (2) by electrolytic "valves." The latter have hitherto fallen short of giving really practical results. The author discusses the various fruitless attempts made to turn this discovery to practical account. In none of the cases, however, was the efficiency above 15 per cent., and the electrodes were rapidly destroyed; much heat was developed, and as many as five cells might be required on a circuit of 100 volts. In 1899, Nodon took up the subject at the Sorbonne, and ultimately reduced the active surface to a minimum, with a large opposed surface of graphite. The active surface is an alloy of zinc and aluminium, and the electrolyte is a solution of a phosphate. During one-half period a pellicle of a double phosphate of zinc and aluminium is formed on the active electrode, and obstructs the current; at the next this is removed and the current passes. While the current is obstructed, the cell takes an electrostatic charge like a condenser; and a second circuit, of different resistance from the first, will take this charge off as a second rectified intermittent current. The currents produced can be used for electrolysis and to charge accumulators, but they produce effects of self-induction, Foucault currents, and hysteresis. The appliance can be used for pressures up to 2,000 volts, and the efficiency is 80 to 95 per cent.; the weight is 4 kg. per kilowatt at 500 volts. The electrodes do not wear away (except the graphite, very slightly), and the electrolyte does not alter. The temperature, however, must not rise above 30° C. A. D.

REFERENCES.

2283. *Alternator Design.* **G. Grassi.** (Elettricità, Milan, 20. pp. 330–333, May 25, and 376–379, June 15, 1901. Paper read before the A.E.I. at Turin, March 2, 1901.)—The paper gives a large number of formulæ for determining the dimensions of the armature of an alternator, and gives expressions for the eddy-currents in iron and copper. G. H. B.

2284. *Leakage Flux of Three-phase Winding.* **J. L. la Cour.** (Elektrotechn. Zeitschr. 22. pp. 553–554, July 4, 1901.)—A letter criticising Niethammer's method [see Abstract No. 1808 (1901)] of calculating the leakage flux, and suggesting certain corrections. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2285. *Long-Distance Power Transmission.* **F. A. C. Perrine.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 501–509, June and July, 1901.)—A clear statement is given of the main difficulties to be overcome in designing long-distance power transmission schemes. When the voltage rises above 30,000, the problem of suitable insulators is an exceedingly difficult one. The insulators, which are of glass or porcelain, must have a diameter of at least 12 or 13 inches, and be held about 8 inches above the cross-arm. It is difficult to make them of sufficient mechanical strength. Also the energy losses due to brush discharges makes the use of wire less than $\frac{3}{8}$ inch in diameter prohibitive. The lines have to be constantly patrolled, and a right-of-way almost as wide as a railroad secured. Unless the capacity current is neutralised by reactance coils, the transmission at light loads is commercially impracticable. Oscillograph pictures of actual current waves show ripples due to the armature slots in the generator. A synchronous motor with a bad wave form took "full load" current at no load. The difficulty was remedied by putting a reactance coil in parallel with the lines. A. R.

2286. *Storage Batteries in Electric Power Stations, Controlled by Reversible Boosters.* **J. S. Highfield.** (Inst. Elect. Engin., Journ. 30. pp. 1040–1074; Discussion, pp. 1075–1096, Aug., 1901.)—This paper is written with the object of showing the chief points to be considered in the design of batteries for central station work, and to describe subsidiary apparatus for use with batteries. It is stated that it has generally been the practice to instal a battery, having a capacity (reckoned at the three-hour rate of discharge) of but a small proportion of the whole station plant. As the load increases year by year, this battery usually comes in for a good deal of ill-treatment, and is soon irreparably damaged. The use of regulating cells with batteries involves the adoption of costly switches and connections, while at the same time these cells depreciate more rapidly than the others owing to difficulties of charging, &c. To obviate the disadvantages of regulating cells, the author has used a variable pressure booster, which is described. By regulating the station pressure by the booster and battery, the generators may be run at full load almost automatically, provided always that the battery is of proper capacity. The battery serves three purposes: (1) To control the station pressure; (2) to carry the peak and allow of the generators being run fully loaded; (3) to carry the whole load when within its capacity. In lighting stations, the battery steadies the pressure considerably when large motors on the mains are started up, and is a source of security when faults are burnt out on the system, saving the generators and minimising the fall in pressure. Curves of cost per kw. of batteries complete with reversible booster, for varying rates of discharge, are given, and assuming £35 per kw. as an average figure for cost of steam and electric plant, it is stated that the battery costs for a three-hour rate of discharge will be the same, decreasing as the size of the battery increases. For the rate of discharge mentioned, the battery, in a lighting station, should have a capacity of at least one-fourth to one-sixth of the

maximum load on the station. It will then safely carry the peak for three hours. The battery losses are amply compensated for by the better load factors of the engines and steam-raising plant, besides which a shift of men may be often saved. The author advocates the adoption of steam units of a uniform size, and a battery of the capacity of a steam set for three hours, being about one-eighth of the capacity of the station ultimately. The battery capacity may be less in large stations. The nature of the all-night load also determines the ratios. The measured efficiency of a battery, from July to December, is given as 74 per cent. The author believes in charging at a greater current than the makers specify, at commencement, and finishing at quite a small current. The convenience of the battery when repairs have to be done to steam plant is alluded to ; also the saving of copper in feeders by installing batteries in substations. For traction stations, the batteries may discharge at the one-hour rate normally, and the cost be taken at this rate, which will give £15 to £18 per kw. Curves are given, illustrating variation of voltage on charge and discharge at various rates, also on sudden variation of the load. An ideal arrangement of working is mentioned, and a special booster described which will enable this arrangement to be approximated to. Curves showing the results of the working of this machine are appended, and for the month of March various percentages proving the efficacy of the system. It is stated that the ultimate object of the booster is to correct for the varying characteristic of the battery, which is here discussed. The fluctuations of the current taken by the booster motor are considered, and it is mentioned that the booster brushes work without lead and do not spark with a current of 200 amperes when there is no field. In the case of tramways operating 400 cars and upwards, the battery would only be useful in the central station for carrying night loads, &c., but separate batteries in substations would enable each route to be worked as a small system, saving copper in the feeders and obviating the necessity of rail-boosting. The same arguments apply to loads on converters fed from a high-tension transmission system. On a *railway* system the substations ought to be near the load centres. In a combined station the batteries should be interchangeable to either load. Shunt-wound generators may be used all round. Cost of battery depreciation is stated to be 7 per cent. per annum. A curve showing the connection between running costs and plant load factor is given. The increased efficiency of the battery on intermittent loads (over 81·4 per cent.) appears to arise from the fact that the pressure due to the gas effect is utilised on short discharges. In the appendix the units of a combined station are tabulated, and a second table shows the ratio of battery to steam plant in some direct-current stations. In the discussion which followed some references were made to the previous use of boosters for the same purpose.

B. P. S.

2287. *Pressure Regulation in Distributing Networks.* **E. Vollhardt.** (Zeitschr. Elektrotechn., Wien, 19. pp. 330–332, July 7, and pp. 341–348, July 14, 1901.)—It is usual, in calculating the pressure drop along a distributor, to assume that the two feeding-points which it connects are maintained at the same p.d. The calculation is generally carried out on the assumption that all the current-consuming devices are in circuit simultaneously. But if one portion of the distributing network should happen to be heavily loaded at a time when the remainder is lightly loaded, the p.d. at the various feeding-points will no longer be the same, and a much greater drop of pressure may occur along a distributor than that calculated on the assumption of equality of p.d.

t its two ends. The practical remedy is to connect the feeding-points by eans of an extra *equalising* main. The author gives an account of the theory f such equalising mains developed by Teichmüller [see Reference No. 1457 1901)], giving formulæ for calculating their size in order to maintain the ressure drop within prescribed limits. A. H.

2288. *Refuse Destructors and Electric Light Stations.* **J. S. Highfield.** Electrician, 47. pp. 606–607; Discussion, pp. 607–609, Aug. 9, 1901. Paper ead before the Municipal Electrical Association at Glasgow, June 21, 1901.) —The author draws attention to some points in connection with the design of uch stations, and gives figures showing the results of working at St. Helens.

FIGURES FOR ONE YEAR'S WORKING OF A TWO-FURNACE REFUSE DESTRUCTOR.

	Total for year.	Average per week.
Weight of refuse burnt	9,778 tons	188 tons.
Electric energy used to drive fan and other motors	70,000 units	1,346 units
Units generated by steam	365,000 „	7,019 „
Wages on burning	£750	£14 8s. 6d.
Wages on repairs	£86	£1 13s. 1d.
Total wages	£836	£16 1s. 7d.
Weight of clinker produced	3,900 tons	75 tons.
Value of mortar sold	£221 9s. 8d.	£4 5s. 2d.
Value of electric units generated at 0·3d. per unit generated	£450	£6 13s. 1d.

Averages per ton of Refuse Burnt.

Units generated	37·3
Units used on works	7·1
Cost of burning (including wages, light and power)	22·1d.
Cost of repairs (wages and stores)	3d.
Total cost of destruction	25·1d.
Cost of removing clinker not otherwise used	5·5d.
Total cost of destroying refuse and removing part clinker	30·6d.

These figures do not include the cost of carting the refuse, which is stated to be 2s. 6½d. per ton. [See also Abstracts Nos. 1797 (1899) and 2330 (1900).] W. H. S.

2289. *Capacity Currents Influenced by Frequency.* **T. Mather.** (Elect. Rev. 48. pp. 915–917, 1901.)—The author noticed that increase of speed of an alternator was sometimes accompanied by a diminution of the condenser current in the cable, whereas the opposite would have been expected. To explain this he made experiments on ten paraffin paper condensers having 50 mfds. capacity, with an alternator giving a wave, the shape of which showed a very large third harmonic in anti-phase. The p.d. on the condenser was kept constant, and the power taken by it for different frequencies noted and plotted as a curve. The character of these curves shows that the capacity current is abnormally high with the peaky wave. It was found that at a frequency of 28 and 118 respectively the condenser currents did not differ much from the normal values given by the formula—

$$\text{Microfarads} \times \text{R.M.S. voltage} \times 2\pi \times \text{frequency} \times 10^{-6},$$

but at a frequency of 81 the current is 6·15 amperes instead of 2·3, the former

being 2·68 times the latter. Well-defined maxima of current appear at frequencies of 49 and 37. The frequencies at which these maxima occur are in the ratios $\frac{1}{3} : \frac{1}{4{\cdot}95} : \frac{1}{6{\cdot}57} : \frac{1}{8{\cdot}54}$ thus naturally suggesting that they were due to the third, fifth, seventh, and ninth harmonics in the e.m.f. wave of the machine. The self-induction h of the machine measured in henries is given by the resonance formula $hFp^2 = 1$, where F = capacity in farads $= \frac{49{\cdot}4}{10^6}$ and $p = 2\pi$ times the frequency of the harmonic considered. The magnitudes of the maxima of a current are proportional to the magnitudes of the harmonics, and this suggests a method of analysing alternator curves by the aid of a current-frequency curve. Special attention is called to the dangers to which cables are exposed from the possibilities of resonance effects with the higher harmonics, although the capacity may be too small to produce resonance at the normal frequency. For the capacity required to produce resonance is inversely as the square of the frequency, *e.g.*, the fifth harmonic will resonate with 1/25th of the capacity required by the fundamental. It is to be noted that a resonating component sends a current through the system, depending only on the ohmic resistance of the system and on the magnitude and frequency of the component, so that currents and p.d.'s on the cable may become large quite unexpectedly through small changes of speed, or through change of inductance or capacity caused by the switching on or off of transformers or cables. M. O'G.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2290. *New Transformer Station of the Niagara Cataract Power and Conduit Company.* **F. P. Woodbury.** (Amer. Electn. 13. pp. 385–388, Aug., 1901.) —The station receives about 14,000 kw. by three-phase transmission from the power-house at Niagara Falls, at an e.m.f. of 22,000 volts, and delivers it 11,000 volts three-phase to the underground system of the City of Buffalo. The three transmission lines, of three conductors each, after entering the building (Wurtz lightning arresters being connected close to the point of entry) pass to the circuit-breakers at the top of the switchboard panels. Below each circuit-breaker is a selector switch for delivering the current to either of the two batteries of transformers—each battery consisting of three transformers (each of 2,250 kw. capacity), with an additional one in case of emergency. The construction of these switches is shown ; they are specially designed to avoid the accidental closing of a circuit, and are operated by means of a hook at the end of a long wooden pole. Static interrupters are interposed between the high-tension bus-bars and the transformers. These consist of a choking coil in the main circuit, with a condenser, of which one pole is connected to the main between the choking coil and the transformer, while the other pole is earthed through a fuse. On the secondary switchboard (which is of similar design to the primary) the current is brought to bus-bars through selector switches ; the terminals of these are earthed through a condenser and fault detector. From the secondary bus-bars the current passes through feeder switches, series transformers (the secondaries of which are connected with ammeters and recording wattmeters), and current-breakers (which are fixed in a separate gallery) to the outside circuits. The pressure of the secondary circuits is indicated by two voltmeters, connected with the secondaries of transformers, of ratio 12,000 to 100 ; these also feed the shunt circuits of the two recording wattmeters. All the instruments are on the secondary board.

The circuit-breakers for the feeder circuits are fitted with a clockwork mechanism, which will only allow the circuit to be opened if the overload continues for a predetermined time, for which the relay is set.

The circuit-breakers on the primary circuit are similar to those on the secondaries, but are, in addition, provided with reverse current relays. These are constructed like a wattmeter, the shunt coil being excited from an outside, but constant source. The series coil is in series with the secondary of a series transformer whose primary is in the line. Should power be forced backward through the circuit-breaker from some other line, owing to a short circuit on one of the parallel lines, the reverse current relay will connect a battery to the time-limit relay, and if the reversal of power continues beyond the period of time-limit, the circuit-breaker will be opened through the time-limit relay, as in the case of an ordinary overload. The plant is of Westinghouse design and construction.

The paper is illustrated by photo blocks and diagrams of connections.

B. P. S.

2291. *Hagneck Electricity Works.* **H. Rupp.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 937–947, July 6, 1901.)—The works, which are near Aarberg, in Switzerland, are fully described with the help of twenty-two plans and photographs. There are five double turbines with vertical shafts by Bell & Co., each of 1,300 h.p. They are directly coupled to three-phase "umbrella" type generators designed for 8,000 volts at 40 ∿, and are excited by four-pole machines at 120 volts. The electrical plant is by Brown, Boveri & Co. The distribution is by the usual overhead system to transformer chambers. Light and power are supplied at the following prices :—

LIGHTING.

Price of one lamp in francs per annum.

Number of Burning Hours.	Normal Candle-Power.			
	10	16	25	32
Over 1,000	13·5	21	33	42
400 to 1,000	10·5	16	25	32
Under 400	7	10·5	16·5	21

POWER.

Demand in h.p.	1/10	1	10	100
Price in francs per h.p. per annum ...	270	210	185	145

W. W. H. G.

2292. *Bex-Gryon-Villars Electrical Works.* **K. A. Breüer.** (Génie Civil, 39. pp. 233–239, Aug. 10; and pp. 249–254, Aug. 17, 1901.)—This paper contains a full description, illustrated by thirty-two figures and two plates. Bex is a health resort on the Avançon, a tributary of the Rhone in Western Switzerland. The Avançon is fed by mountain streams and furnishes

abundant water-power. Six Escher-Wyss turbines with horizontal axes each give 400 h.p. at 600 r.p.m., and are directly coupled to the generators. Four are Westinghouse three-phase machines for 5,000 volts at 50 ∼. The other two are direct-current dynamos of the Thury type, with six poles, and give 300 amperes and 650 volts. Exciting current for the alternators is furnished by small dynamos of the Manchester type, driven by extensions of the main shafts of the turbines.

All the lighting is obtained from one of the phases, the alternators being so wound that the full power of the turbines can be carried either by one or by the three phases. The distribution is by overhead lines which include: (1) A line of three wires, 7·75 km. in length, supplying a chemical works at Monthey and a transformer at Bex. (2) A single-phase line supplying the substations at Châtel, Lavey-Village, and Lavey-les-Bains. (3) A single-phase line for lighting Posses. The sale of energy is by a special tariff without meters. An important part of the undertaking is an electric railway of 12·5 km., of which 4·9 km. is a rack of the Abt type. The trolley line is fed at 600 volts from the Thury machines. Descriptions of the motor cars and electric locomotives are given. The electrical equipment is by the Compagnie de l'Industrie Électrique at Geneva. The regulating resistances are prevented from overheating (especially during the descents) by using a small electrically driven fan. W. W. H. G.

2293. *Hoylake and West Kirby Electricity Works.* (Elect. Engin. 28. pp. 222–227, Aug. 16, 1901.)—This station has an engine-room 50 ft. by 33 ft., a boiler-house 50 ft. by 48 ft., a battery-room 29 ft. 6 in. by 16 ft., and a pump-room 25 ft. by 14 ft. The chimney has an internal diameter of 7 ft., and a height of 125 ft. There are three Lancashire boilers 28 ft. by 7 ft. 6 in. with superheaters, and an economiser of 192 tubes. There are three 75-kw. steam alternators; running non-condensing, they take 32 lbs. of steam per kw.-hour at full load. There is also a motor-generator for receiving alternate and delivering continuous current, and *vice versâ*. The continuous current is used for charging a battery, which in its turn drives the motor-generator set when the steam plant is shut down. The battery has 120 cells, giving 100 amperes for five hours. Two feeders have areas of 0·1 and 0·15 square inch, and the distributors have either 0·15 or 0·1 square inch section. The article contains several drawings showing arrangements of the power-house, and connections and details of the switchboards. W. H. S.

2294. *Milan-Gallarate-Porte Ceresio Railway.* (Street Rly. Journ. 18. pp. 99–106, Aug., 1901.)—The steam railway between the above points has been converted to an electrical system, the current being conveyed by a third rail. The power-station is situated at Tornavento, which is on the River Ticino, and at a distance of about six miles from the line. At Tornavento it is intended later on to utilise water-power; but at present the machinery is driven by steam. There are three 750-kw. polyphase generators coupled to Corliss engines; the power is distributed through rotary converters. The article contains drawings of the insulators for the third rail and for the overhead transmission lines, and also of the connections on the various switchboards. W. H. S.

2295. *Water-Power Installation at Poses-sur-Seine.* **E. Bret.** (Génie Civil, 39. pp. 265–270, Aug. 24, 1901.)—A description of the way in which the

vailable head of water (about 0·8 meters at the minimum) is utilised at Poses-ar-Seine for working a lock on a navigable arm of the river which joins the eine at this place, and also for working the sluices of a dam across the main ver. The turbine which works the dynamos is of the Fontaine type, eveloping a maximum of 30 h.p. under the best conditions, but never falling elow 12 h.p. A vertical shaft with bevel gearing transmits the power of the enerators, increasing the speed at the same time from 25 to 900 r.p.m. The wo dynamos, one of which is a standby, are of the vertical Gramme type, hunt wound, each capable of giving 40 amperes at 275 volts. The speed of he turbine is regulated either by hand or automatically by means of a small eries dynamo. This is effected through a vertical shaft by means of which he angle of the vanes can be altered. The switchboards are arranged so as o allow the dynamo current to be switched on to a battery of accumulators, r on to the distributing mains, or both together. They are provided with urrent interrupters, fuses, lightning protectors, fault indicators, and volt and mpere meters. They also include pressure regulators (both hand-worked nd automatic) a current reverser as an adjunct to the latter—the object of vhich is to reverse the current at the field of the motor which controls the urbine in case of the variations becoming excessive—and an automatic rrangement by which cells are thrown in to raise the pressure in case of the .m.f. of the dynamo falling too low. The battery consists of two groups of ells of the Jacquet type, each group having 54 cells, and each cell having 11 lates with a weight of 34 kg. The cells are mounted on oil insulators. They can be charged in series of 48 cells, and discharged, either with the vhole of the cells in series, on the motor circuits, or with the two halves of he battery divided, on the lighting circuits, which are arranged on the three-vire system. In the latter case the number of cells employed in each group is educed, as the lamps are run at 110 volts. The total candle-power of the amps installed, which are all used for lighting the locks, or the dam, or lifferent parts of the works, is about 1,000.

The large dam, over 200 metres in length, and with a fall at times of over 4 metres, is of the Caméré type, and the movable sluices are worked by three notors, two of 3 h.p., and one of 7 h.p. Of the three existing locks, the argest only is electrically worked. The lock-gates, of which those at the pper end of the lock are 7·2 metres high and those at the lower end 8·85 netres, both being nearly 7 metres wide, and also the sluices, are operated hrough bevel gearing and racks and pinions by a single motor of 3,250 watts apacity, from which the power can be transmitted for either purpose by two ets of friction gearing—a method which has been adopted as giving the ecessary flexibility of working. The current taken by the motor is found o be from 3½ to 4 amperes at 274 volts during the raising of a sluice, and bout 2½ amperes while it is being lowered ; from 5 to 6½ amperes are taken luring the opening, and from 3 to 3½ during the closing, of the lock-gates. Four windlasses are erected at the sides of the lock, each worked by a 7 h.p. notor placed in an underground chamber alongside the windlass, which is lriven by a worm gearing. A 2-h.p. motor drives a few machine tools in the epairing shop, and one of 4 h.p. has been installed to drive a rotary pump in onnection with an establishment for pisciculture. Statistics are given howing the saving in time and labour which has been effected by the doption of electricity in the working of the lock-gates and sluices, with an nalysis of the cost of the whole installation. The paper is well illustrated vith photograph, diagrams of connections and detail drawings of the nachinery and gearing.

B. P. S.

2296. *Toledo and Monroe Railway.* **W. S. Conant.** (Street Rly. Journ. 18. pp. 84–90, Aug. 1901.)—An interurban electric railway, about 20 miles long, is here described. A 400-kw. alternator is installed, and distributes power through rotary converters. Two good drawings of the power-house are given. (See also Elect. Rev. N.Y. 39. pp. 246–250, Aug. 31, 1901.) W. H. S.

2297. *Naples-Aversa-Caivano Electric Railway.* **C. Pio.** (Street Rly. Journ. 18. pp. 79–82, Aug., 1901.)—General particulars are given about two short electric lines, each about 15 miles long, connecting Naples with Aversa and Caivano. The power-house contains four 225-kw. units; two of these are direct-current and two are alternate-current generators. Synchronous motor-generators are installed in substations. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

2298. *Tramway Track Construction.* **W. Howard-Smith.** (Elect. Engin. 28. pp. 91–94, July 19; 129–131, July 26; and pp. 194–197 (with Discussion), Aug. 9, 1901. Paper read before the Association of Municipal Engineers at Leicester.)—This paper contains much useful information connected with the question of track construction. With regard to rails, a weight, of about 95 lbs. per yard is perhaps the most usual and the best. The author urges the importance of having a standard rail, and gives a drawing of one which might be adopted, having been largely used lately by the British Electric Traction Company. Of late, grooves have been somewhat widened, the Board of Trade having approved some which were $1\frac{1}{4}$ inches in depth and width. For curves of from 75 feet to 50 feet radius, this groove should be sufficient, and curves of smaller radius should never be employed. Wheels of 30-inch diameter on a 6 ft. 6 in. rigid wheel base, with $\frac{3}{4}$-inch flange, running in a $1\frac{1}{16}$-inch rail groove, commence to bind against both sides of the groove at 66 feet radius. Vignoles rails should be used in the car-sheds, having detachable guards bolted on, if necessary; in this way sharper curves are possible. The author is of opinion that 45-feet rails are probably the best on the whole; in any case, the question of expansion is of no importance, owing to the small area of rail surface which is exposed, and the number of joints should not affect the question on a well-constructed track. The design of turn-outs is fully dealt with, and a drawing is given, accompanied by a table showing the various dimensions for diamond turn-outs with various angles of crossing. The author has found 1 in $5\frac{1}{2}$ to be a good angle for town lines, while he prefers 1 in 7 for suburban lines, working at higher speeds. Concrete composed of 6 of aggregate to 1 of cement under the rails is recommended, and of 8 to 1 under the paving, the depth being 6 inches below the rail, and 4 inches to 6 inches below the paving. The best method of laying the concrete is to first lay the rails to their proper aligment and level, temporarily supporting them at intervals; the concrete is then to be thrown in to the right level, men being told off with strong spades to make it solid under the rail base. The life of rails with electric traction is not yet properly ascertained, but the author thinks that where the frequency of service is five minutes or less, and the traffic heavy, rails should last 8 to 12 years on straight lines, with gradients less than 1 in 40; for 6 to 10 years for steeper gradients; and for 2 to 6 years on curves having radii less than 66 feet. Fishplates are now

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

enerally supplemented by some form of soleplate; the rigidity of the joints a matter of the first importance, the life of the joints being practically the fe of the track. The author gives a detailed estimate of the cost of con-ruction of track; for a 3 ft. 6 in. gauge, this amounts to £5,096 per mile of ngle track. A long table is also given, showing analytical particulars of ome of the most recent sections of girder rails used in this country. The riginal paper should be consulted for information on rails, rail lengths, rail oints, springing of rails, bolt-holes, fishplates, tiebars, curves, points, turn-outs, oncrete foundations, wheel tyres, &c. W. H. S.

2299. *Mixed Trolley and Conduit Systems.* **A. N. Connett.** (Inst. Mech. Engin., Proc., 2. pp. 375–396; Discussion, pp. 397–425, Feb.–May, 1901.)—From a working point of view the author prefers a centre slot to a side slot. In the latter there is difficulty with the switches; the plough or conduit receives more mud or water on account of the wheels; and the slot rail, being also the wheel rail, requires a vertical web which renders inspection more difficult. But owing to the elimination of the band of iron in the centre of the track the side slot is sometimes specified by municipal authorities.

In practice the switches are responsible for most of the interruptions in service, and therefore arrangements must be made so that the switching is effective; or, if it fails, so that the plough automatically disengages itself. In the case of a side slot, it is better to deflect the slot to the centre just before the car switch is reached.

In a mixed line it is necessary to have a plough which can be withdrawn at the end of the conduit. Ploughs may be made with "flappers" so that they can be withdrawn though a $1\frac{1}{4}$-inch slot without any additional opening, but the construction is cramped, and therefore unsatisfactory. The best form of plough is one having soft cast-iron shoes pressed lightly against the vertical faces of the conductor bars by semi-elliptic springs placed horizontally. With regard to distribution, the conduit should have a separate circuit, which may be supplied by a separate dynamo, or by a motor generator suitably placed. It has been found that conductor bars of mild steel, connected by two bonds at each joint, have a carrying capacity of about one-eleventh of copper bars of the same cross section. The carrying capacity may be increased by attaching to them bare copper cables. The author gives an account of the mixed system which he laid down in Paris [see Abstract No. 766 (1900)].

The cost of a side slot is about £500 per mile less than the centre slot. There is also an economy in frogs unless the slot is deflected to the centre, when the cost is greater. Under ordinary conditions, including the cost of special track work and the removal of underground obstructions, the additional cost of a conduit over a trolley system will vary between £7,000 and £9,000 per mile of single track. The author gives details of cost for the Metropolitan Railway of Washington (£9,946 per mile of single track), some details of cost of the Second Avenue Railway of New York, and an estimate of cost for England (£16,484 per mile of single track).

Discussion.—**E. K. Scott** suggested certain modifications and gave sections of the conduit at New York and Paris, and of the Westinghouse Company. **R. T. Smith** stated that there was no difficulty in cleansing a conduit like that at Brixton for £60 per mile [per annum], and suggested that it might be worth while to have a shallower conduit on account of obstruction and to pay more for cleaning. **J. E. Waller** was in favour of a flexible conductor, and objected to the side slot. He thought that the cost of conduit construc-

tion as given by the author was put at too high a figure, and gave estimates showing that the additional cost of the centre conduit as compared with the trolley was £5,461 per mile of *double* track, which would reduce to £4,437 for side slot, excluding special track work, temporary track, obstructions and feeder-ducts. The **Author,** in reply, mentioned that a central slot of $\frac{3}{4}$ inch should be gauged in construction to $\frac{7}{8}$ inch, owing to the tendency to close. Trouble had been caused by ploughs breaking down in insulation. In Paris it had been found advisable to use a double set of ploughs, changing them each night, so that they might be dried after each day's run. As to cost of running; at Brussels the conduit cost $1\frac{1}{4}$ farthings more per car-mile than the trolley system; including the fixed and amortisation charges this came to 2·9 farthings per car-mile. In Washington the cost of cleaning conduits amounted to £5 10s. per annum per mile of single track. The author was of opinion that a depth of conduit of 8 to 10 inches was necessary below the conductor rails. He did not believe that it was necessary to have the running rails carried by the yoke in centre slot construction. Flexible conductors would only increase the cost. He did not think that the conduit for which J. E. Waller had estimated would be strong enough. W. R. C.

2300. *Electric* v. *Steam Traction on Railways.* **E. Cserhati.** (Écl. Électr. 28. pp. 130–140, July 27, 1901.)—The author considers the problem from the point of view of running costs, assuming that three-phase motors are used. The economy in fuel should be considerable, for the best compound locomotives require 8 kg. of steam per h.p.-hour measured at the tread of the wheel, which figure may increase greatly with unfavourable conditions of working, whereas, allowing for inefficiencies in transmission and transformation, an electrical h.p.-hour measured in the same way can be obtained under almost all the varying conditions found in practice for 8 to 9 kg. of steam at the power station. In most steam locomotives used for slow service, the steam consumption is about 50 per cent. greater. Apart from the question of steam consumption, there is much greater efficiency in a stationary boiler than in a locomotive boiler, and standby losses are much reduced, so that there is a considerable saving in coal by the use of a power station.

The suppression of the tender alone means 20 to 50 per cent. less weight in the locomotive. The weight may be still further reduced, for although the proportion of weight used in tractive effort does not exceed 16 per cent. in the case of steam locomotives, this figure rises to 25 or 30 per cent. for electric locomotives, as shown on the Baltimore-Ohio line. Since the turning moment of the motor does not vary as the latter rotates, a greater tractive effort can be obtained for a given weight than with steam; also the coefficient of friction seems to be increased by the passage of the current from the wheel to the rail. The friction of the working parts is also less. Actual results show that the weight per unit of tractive effort is 100–110 kg. for steam locomotives, whereas it is only 66 kg. for electric locomotives, and 33 kg. for railway motor cars.

Among other advantages of electric traction may be mentioned the return of energy to the line by three-phase motors instead of loss by braking, lower maintenance charges on fixed boilers, and on motors as compared with exposed steam mechanism, less deterioration of rolling stock generally and permanent way, reduction in staff, and easier handling of traffic. W. R. C.

2301. *Storage Batteries in Traction Systems.* **G. A. Grindle.** (Inst. Elect. Engin. Journ. 30. pp. 1098–1127, Aug., 1901.)—The author refers to the

adoption of storage batteries for vehicles carrying their own sources of power and to early attempts at transmitting power through a third rail, or overhead, conductor, but the main object of the paper is to deal with the function of the secondary battery as a governor in an electric traction system, whereby it maintains a steady and economical load on the generators.

The necessity for a battery and the advantages to be obtained from it are discussed, and the question of cost entered into, showing a saving in operating plant. This result is arrived at by assuming £30 per kw. as the cost of steam plant, and £12 per kw. for battery plant (including booster, &c.); the relative working lives of both plants, however, and also the cost of upkeep in both cases, being left out of account. It is pointed out, however, that less spare plant is required when the battery is adopted.

The case of batteries in substations is considered, with the conclusion that large savings may be made in feeders on account of the copper only being required to carry the normal generator load. The saving to be made in cost of operation is obvious, as the engine load factor is always high, and the reduction in coal consumption on this account is given as 75 per cent. The battery losses are given for an actual case and are very low, the efficiency of units used to those generated being 91 per cent.

The author indicates what the relative proportion of the battery to station capacity ought to be, and then shows how the battery ought to be employed, whether in the power station or a substation. The cases of regulating either by cells, an ordinary booster, or a differential booster, are then examined, and the opinion is expressed that the last is the proper way to work. It is stated that the working conditions under the last system are most favourable to the life of the battery. Diagrams of load variation are given, showing the steadiness of the generator load when the differential booster is used.

Plates of the Planté type are recommended, owing to the small resistance of the cells, and their capability of standing high rates of charging. So far the reversible booster, as arranged by J. S. Highfield, is said to be the best. The author concludes that the battery should be the real regulator of the system, and that the engines should run at constant steam admission and pressure. B. P. S.

2302. *Electrolysis by Earth Returns.* (Eng. Record, 43. p. 545, June 8, 1901. Extracts from Prof. **Caldwell's** Report on Electrolysis Survey at Columbus, Ohio.)—Caldwell made numerous measurements of the volts between the tramway rails and water-pipes, and of the currents in the pipes. A table of the results is given, showing currents up to 8 amperes in certain pipes. The difference of potential between rails and pipes was much greater where the bonding was imperfect. The recommendations made are as follows: (1) Bonding must be maintained in good condition. (2) The drop of potential in the rails must be kept small by numerous insulated return feeders. (3) There should be no earth at the power station. (4) The rails should be laid in concrete or other poor conductor. (5) There should be no connections between the rail and water-pipes.

As regards the water-pipes, the recommendations are: they should be laid as far as possible in side-streets; the bells should be laid towards the direction in which the current will flow, so that electrolysis, if any occur, will be at the ends of the bells, where it would be least injurious; in making joints, the coating on the pipes should be kept intact, and the pipe, for six inches on either side of the joint, should be given a coating of asphalt. G. H. B.

2303. *Electrolysis by Earth Returns at Peoria, U.S.A.* (Street Rly. Journ. 18. pp. 65–69, July, 1901).—This is the report of the Master in Chancery on the case of the Peoria Water Company *v.* the Central Railway Company for an injunction to stop the latter from damaging the water-pipes of the former company by electrolysis [see Abstracts Nos. 581 (1901) and 2518 (1900)]. The report shows that damage has been done, and that electrolytic deposits have been found. Potential differences between the pipes and rails have been observed up to 45 volts. This upper limit was reduced to 35 volts in 1899, but, needless to say, the injury still continues. Since the evil can be remedied by the double trolley, the Master's conclusion is that the injunction should be granted. W. R. C.

2304. *Effects of Poor Rail-bonding.* (Eng. Record, 43. pp. 601–602, June 22, 1901.)—Two cases are described where the bonding of tramway rails had so deteriorated that differences of pressure, amounting to 10 volts, were set up between the rails and neighbouring water-pipes. Full details are given, with diagrams. G. H. B.

2305. *Starting Resistances for Car-motors.* **M. Kubierschky.** (Ind. Élect. 10. pp. 372–378, Aug., 1901.)—The author refers to a paper by Bunet [see Abstract No. 1397 (1901)], in which a formula was given to determine the values of the resistances in the successive steps of a rheostat, in order to insure that the variations of current when starting a car-motor should not exceed certain fixed limits.

The author points out that the results given in that paper are unreliable owing to the writer having neglected, as unimportant, the variations in the magnetic flux in the motor produced by variations of the line current; and he shows graphically by means of curves—the actual characteristic of the motor used by Bunet, and the curves of effort and speed—that the variation of magnetic flux must be taken into account. Taking a concrete example, it is shown that a car of eight tons weight, which would require, according to Bunet's calculations, six steps in the rheostat to start it, with a variation of current of 50 to 70 amperes, would, with the above permissible variation of current, actually require no more than three steps to bring it up to speed. B. P. S.

2306. *High-Speed Electric Railways.* **L. v. Reymond-Schiller.** (Zeitschr. Elektrotechn., Wien, 19. pp. 206–210, April 28; 317–321, June 30; 380–382, Aug. 4; 388–391, Aug. 11; and pp. 400–406, Aug. 18, 1901.)—The author considers the scheme of Zipernowsky, proposed in 1891, for an electrical way between Vienna and Budapest at 250 km. an hour. He then discusses the general question of high speed electrical railways, and classifies the various systems proposed, with special reference to those of Langen and Behr. He introduces for consideration an extensive scheme for a "Central-European-Electrical-Continental Railway," to include a network from east to west, the following being the routes, which are shown on a map:—(1) Budapest—Raab—Pressburg—Vienna. (2) Vienna—Prague—Dresden—Berlin. (3) Berlin—Magdeburg—Hanover—Cologne—Namur—St. Quentin—Paris. (4) Vienna—Munich—Carlsruhe—Strassburg—Mulhausen—Belfort—Chalindrey—Paris. (5) Chalindrey—Chalons—Lyons—Valence—Avignon—Marseilles. The author next considers the question of the width of track necessary for a speed of 250 km. an hour. Examination of the accepted data, and the application of

Hoffmann's formula, prove that a wide gauge is necessary so as to keep the tractive effort small; and it is finally shown that a gauge as wide as 4·5 m. should be used. W. W. H. G.

2307. *Electric Traction on the Bologna-San Felice Railway.* **D. Civita.** (Elettricità, Milan, 20. pp. 409–411, June 29, and pp. 421–424, July 6, 1901.)—The Bologna-San Felice Railway is 42½ kilometres in length, and is worked by accumulator motor cars. Details of the electrical equipment were given in Abstract No. 1208 (1901). The present paper contains an account of some experimental runs, with full details and curves. The following table is a summary of the results :—

Total distance run, km.			84·960
Weight of motor-car, tons			46·046
„ trailer „			7·930
	Out.	Return.	Total.
Ton-km. run (out and return)	—	—	42″7
Time of run, excluding stops	79′·26″	83′·59″	163′·25″
„ current supply	50′·30″	60′·30″	111′·00″
„ starting, total	427″	480″	908″
„ „ mean	35·5″	37·0″	36·24″
Watt-hours consumed in running	19,548	22,570	42,118
„ „ starting	3,787	5,163	8,950
„ „ total	23,335	27,733	51,068
Watt-hours, per km.	550	650	600
„ „ ton-km.	11·1	13·2	12 15
Mean speed, km. per hour	32	30·3	31·15

Sixteen kilometres of the line are on gradients of from 0·48 to 0·5 per cent. A battery which had run 10,580 kilometres was examined, and found in perfect condition. G. H. B.

2308. *Electrically-driven Submarine Boat.* **E. P. Weber.** (Centralblatt für Accumulatoren, 2. pp. 146–148, 1901.)—This vessel was built in 1898, and was put through its trials in 1899. The total length with screw is 17 m., and greatest diameter 2·5 m. Steering is effected by one vertical and two horizontal rudders. The screw is connected through a leather coupling with a 30 h.p. motor, supplied with current from a 490-volt battery of accumulators, giving 720 ampere-hours on a 12-hour discharge. There is no room for a charging plant on board. The speed of the screw is normally 450, but can be halved by switching the two halves of the battery into parallel, and can be raised to 485 by weakening the motor field. Reversal is effected by reversal of the field. The starting resistance is of sufficient section to allow of its use as an additional speed-regulator. The depth of immersion is regulated by water-tanks, which can be emptied by compressed air. It has been found that the boat is too small and that the electric pressure is too high, causing excessive leakage from the battery in its damp and confined position. However, continuous trials of several hours' duration were carried out with closed hatches in rough weather. In the construction of such vessels the writer recommends a closer co-operation between electrician and shipbuilder.

W. H. E.

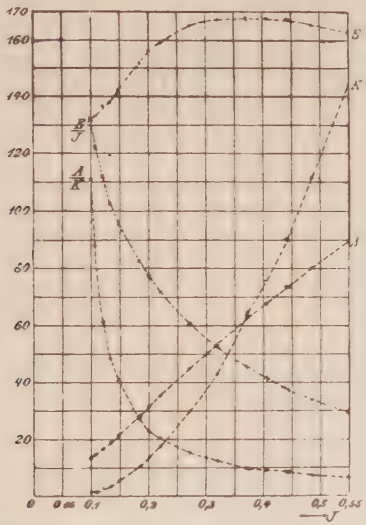
ELECTRIC LAMPS AND LIGHTING.

2309. *Kallmann's Variable Tariff System.* **Kallmann.** (Elektrotechn. Zeitschr. 22. pp. 676–682, Aug. 22, 1901.)—The author first reviews the systems already proposed, and gives a list of the principal papers which have already been published on the subject. His method is as follows: For each month or each quarter, or even merely for the summer and winter half-year, every central station has a characteristic current-supply curve obtained from the readings of the switchboard instruments, which curve shows the mean value of the consumption-curves of all the consumers; that is to say, it gives the average load-curve for the twenty-four hours of a summer's day or of a winter's day. The area of each of these two curves can be expressed in terms of the tariff, in such a manner that a consumer whose mean consumption-curve corresponds to this central-station load-curve, has to pay the calculated average price per kilowatt-hour, which is fixed from the calculation of the distribution of the fixed and current annual expenses of generation supply and distribution. If the mean consumption-curve of the consumer is below the central station curve, the price for this consumer is correspondingly raised above the average price, since the fixed expenses must be distributed over a small number of kilowatt-hours. Conversely, the price of current is reduced accordingly as the area is greater by which the consumer's consumption-curve exceeds the mean central-station curve. The current so used can be measured by a three-stage or dial meter, or even by a time-measurer having three relays, one of which is actuated, when the current is between 5 and 10 per cent. of the maximum demand, to throw the pointer of one dial into operation, another to be actuated when the current is between 20 and 50 per cent. of the maximum, and a third when the current is over 50 per cent. of the maximum, only one pointer being in operation at a time. A number of numerical examples are given. C. K. F.

2310. *Védovelli's System of Stage-Lighting.* **A. Bainville.** (Électricien, 22. pp. 97–99, Aug. 17, 1901).—In this system, in order to obtain continuously-varying effects, a series of commutators are connected, through friction-wheels on spring-controlled oscillating-frames, to one or other of two shafts rotating in opposite directions, trip-mechanism being provided whereby the frames are released and moved by their springs, so as to bring the friction-wheels out of contact with the driving-shafts, when predetermined points are reached on the commutators; the switch-arms can then be operated by hand. C. K. F.

2311. *The Nernst Lamp.* **W. Wedding.** (Elektrotechn. Zeitschr. 22 pp. 620–624, Aug. 1, 1901.)—The author here gives the results of tests he has carried out on some Nernst lamps. The first set examined consisted of lamps, said to be suitable for lighting small rooms, at 220 volts. The candle-power, with clear glass globes, varied from 24·2 to 55, and the watts per candle (*i.e.*, per Hefner candle), from 1·39 to 1·54. A second set of larger lamps *without* globes included 220-volt lamps, of from 85 to 102 c.p., with efficiencies from 1·01 to 1·2 watts per c.p.; and also 110-volt lamps, of about 70 c.p., with a mean efficiency of 1·4 watts per c.p. The time occupied in lighting varied from 9 to 69 seconds, the average being about 30 seconds. The author then gives a large number of tables and diagrams, referring to the determination of the mean spherical c.p. In the case of a 220-volt lamp *without* globe, the mean illumination in the lower hemisphere was found

be 110·3 c.p., and in the upper hemisphere 96 c.p., the watts consumed ing 192·9. This gives an efficiency of 1·87 watts per spherical c.p.; and ordinary incandescent lamp, similarly tested, had an efficiency of 3·91 atts per spherical c.p., the ratio of the two efficiencies being therefore that 1 to 2·1. The life of the Nernst lamp at the various efficiencies is not ated. The author next examined a filament, which was subjected to a ntinuous change of voltage. The results are shown on the adjoining rves. The various quantities are considered as functions of the current J, hich is the abscissa. They include the impressed voltage E, the candle-ower K, the apparent resistance E/J, the watts consumed A, and the watts r c.p. A/K. The scales of the various ordinates may be ascertained from



ne fact that, commencing at the left hand of the different curves, E is 132, is 0·1, K is 1·19, and therefore A is 13·2, E/J is 1,320, and A/K is 11·1. The mp is intended for a normal voltage of 165. It has a critical point at 168 olts, and if this voltage is reached, the filament will afterwards take 0·51 mpere at 165 volts instead of the normal 0·27 ampere, and will consequently urn out. The existence of this critical point is clearly shown by other iagrams (not reproduced), which treat the variables as functions of the oltage. For the purpose of preventing any dangerous increase of voltage cross the filament, a series resistance is used; and figures are given, showing ne extent to which this resistance increases at the critical point, and thus bsorbs the extra volts. W. H. S.

2312. *The Nernst Lamp.* **A. J. Wurts.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 511–536, June and July, 1901.)—The author gives an account of ne work which has been done with a view to developing the Nernst lamp in merica. The standard 220-volt filament is about 25 mm. long, and 0·63 m. in diameter. It is connected to its terminals by means of a platinum ead, embedded in the end in such a manner that any shrinkage of the lament results in tightening the contact, and thus maintaining intimate onnection between the platinum bead and the filament. With direct urrent, electrolytic action shortens the life of the filament; but with 220-volt

alternating current, it has been found at the Westinghouse works, where some of these lamps are used for lighting the shops, that the filaments last about 890 hours. On continuous current, 220-volt filaments would be expected to last about 300 hours; those for 110 volts are generally less satisfactory. Various curves are given, showing the connection between volts and amperes, when the filament is run, either in air, in a vacuum, in nitrogen, oxygen, or hydrogen. The curves in air and oxygen are the best of the series, and are very similar to one another. It is therefore concluded that it is best to run the filament in air. The steadying resistance, which is placed in series with the lamp, is made of iron wire, mounted in a glass tube filled with an inert gas; it is worked at such a temperature that a 10 per cent. increase in current increases the resistance of the iron wire by 150 per cent. The filament lights at a temperature of about 950° C.; the initial heating is effected by a heater, which consists of a thin porcelain tube, wound with fine platinum wire and painted with cement, the latter serving to protect the platinum from the intense heat of the filament. The heater is disconnected from the circuit by an automatic cut-out, as soon as the filament is lighted. A drawing and full description of the design of cut-out are given; the coil is bedded in cement, and the contact made by a silver band, which falls by gravity between two silver wires forming a V. The lamps at present developed range from a 50-c.p. lamp for 110 volts, with one filament, to a 2,000-c.p. lamp for 220 volts, with thirty filaments. The complicated question of efficiency is next considered. A 220-volt filament, taking 0·4 ampere, required 20 volts more in the open air than when burning with five others in a 3-inch globe, this being due to the fact that in the latter case the filaments are in a highly heated atmosphere. The efficiency of a 6-filament lamp with clear glass globe, but without the dome shade, is 1·2 watts per c.p. measured in the direction of greatest intensity, the total c.p. being 400. When the lamps are first started, they require no attention. After 1,000 hours, the renewals become fairly regular. Alternate-current filaments are expected to last about 800 hours, the heaters for 2,000 to 3,000 hours, and the series-resistance should last for an indefinite time. The cost of a 6-filament lamp will probably be about 14 or 15 dollars, and for other lamps in about the same proportion. W. H. S.

2313. *Bardon Enclosed Arc Lamp.* **J. A. Montpellier.** (Electricien, 22. pp. 81–82, Aug. 10, 1901.)—In this lamp the upper carbon-holder is controlled by a clutch, consisting of a bar having a hole in the centre through which the carbon-holder passes, and feet at one end adapted to rest on the bottom of the case when there is no current in the lamp. The other end of the bar is connected to one arm of a counterbalanced lever, which has the core of the controlling solenoid suspended from its other arm. Two views are given illustrating the connections, and the method of supporting the inner globe. C. K. F.

REFERENCE.

2314. *Lightning Discharges and the Protection of Aerial Lines.* **H. Müller.** (Elektrotechn. Zeitschr. 22. pp. 601–603, July 25, 1901.)—The author discusses the various ways in which overhead lines are affected by atmospheric disturbances, and critically examines the various forms of lightning arresters. A. H.

TELEGRAPHY AND TELEPHONY.

2315. *Bedell's System of Telegraphy.* **Johnson.** (Électricien, 22. pp. 65–70, ug. 3, 1901.)—According to this system of telegraphy, transmission takes lace in a series of pulsations produced by the employment of a battery or ther continuous-current source, the current being modified by the gradual sertion of resistances, or of auxiliary e.m.f.'s, or by the employment, together ith the battery, of an alternate-current generator. The modified pulsations e arranged to form a code, in such a way that they can be received, corded, and interpreted at the distant station. The sending apparatus may ke the form of an automatic transmitter, resembling the Wheatstone erforated slip instrument. Two rows of holes may be used, in addition to e row which is used for actuating the slip, so that the current passing to line hrough one brush can be modified by the simultaneous current passing to ne through the other. The form of the pulsation, transmitted through either rush to line, can be modified by rotating rheostats or by alternators. Various ethods for attaining these results are described. R. A.

2316. *Wireless Telegraphy.* **S. Kimura.** (Phys. Zeitschr. 2. pp. 571–574, ne 29, 1901.)—The author describes experiments he made for the Japanese dmiralty at distances up to thirty English miles. His principal object was o determine the part played by the earth connection. Earth plates of ifferent sizes and materials were tried, the author's telephonic receiver being sed instead of a coherer, and it was found that the ohmic resistance of the earth" was of practically no importance, the strength of the signals being ependent on the size of the earth plate, or rather its capacity. Thus signals ere received from a distance of fifty miles, using as earth three oil tins laid pon the grass.

The author draws the further conclusion from these results, that the etection of signals does not depend only on the potential induced in the eceiving wire, and that in order that tuning may be effected the capacity of e earth plate must be taken into account. He is of opinion that each scillation has its effect in reducing the resistance of the coherer, however igh that resistance may be at the moment, and therefore that increase of apacity, by prolonging the train of waves, increases the sensibility of the eceiver. J. E.-M.

2317. *Wireless Telegraphy.* **L. Lombardi.** (Elettricità, Milan, 20. p. 278–281, May 4, and 291–294, May 11, 1901. Paper read before the ssociazione Elettrotecnica Italiana, March 24, 1901.)—This paper is a historical urvey of the progress of wireless telegraphy, and of the phenomena which ed up to it, from Kelvin's theory of oscillatory discharges, published in 1853, o Slaby's and Braun's improvements in Marconi's system of telegraphy. hese improvements are discussed at some length. G. H. B.

2318. *Rotary Converters* versus *Motor Generators for Telephone-call Signalling.* **. M. Bliss.** (Elect. World and Engineer, 37. pp. 1031–1032, June 15, 1901.) —The old hand or power generator is rapidly disappearing from the xchange, and in its place is found the more efficient and compact rotary onverter or motor generator. Considering efficiency alone, the converter ype of ringer is to be preferred ; but in a machine in which the total input t the motor does not exceed 200 watts the question of efficiency is secondary o that of reliability and insulation. Since the transformation ratio of a rotary onverter cannot be varied, the tendency is to use motor generators for both

charging and ringing purposes. The advantages are enumerated, and a specification is given for a 75-watt machine. J. E. K.

2319. *Thermopiles in Telephone Stations.* **Tuch.** (Archiv Post Tele. 14. pp. 454–463, July, 1901.)—This paper describes the trial by the German Post Office of Gülcher thermopiles as a substitute for primary or secondary batteries in telephone stations. Thermopiles of 50 junctions, giving 3 volts, and of 66 junctions, giving 4 volts, were tried. Curves are given showing the variation of volts, amperes, and watts as the number of microphone circuits increased, for accumulators, primary cells, and different arrangements of thermopiles. It was found that the thermopiles, owing to their high internal resistance, did not furnish a corresponding amount of energy as the number of microphone circuits was increased, and that their first cost, upkeep, and the cost of gas far exceeded the costs of accumulators. The thermopiles are now relegated to the Post Office Museum. G. H. B.

2320. *Telephone Line on Snow to the Etna Observatory.* **A. Riccò.** (Accad. Lincei, Atti, 10. pp. 193–196, 1901.)—The telephone line from the Etna Observatory to Nicolosi, originally erected with iron wire on poles, was frequently broken in high winds when the wire was covered with snow. It was then found that good communication could be maintained by laying the wire on the snow, or, where the snow was not continuous, by nailing it to the poles at a height of 180 cm. Steel wire has been substituted for the iron wire on the poles, and has not yet been broken. G. H. B.

2321. *A Humming Telephone.* **F. Gill.** (Elect. Rev. 48. pp. 951–953, 1901. Paper read before the I. E. E. (Dublin Section), April 18, 1901.)—The author describes further experiments made on the effect first noticed by A. S. Hibbard in 1890, that if a telephone be held near to the diaphragm of a microphone, a hum or whistle once set up is continued. The connections are those ordinarily used, the microphone being in series with a battery and the primary of an induction coil, and the telephone in series with the secondary. The author finds that on reversing either the connections of the telephone or the battery current a change in pitch of the hum is produced, but that if both reversals be made simultaneously no change is produced. For the ordinary humming the exact conditions that determine the note given out appear to be very complex; apparently every portion of the circuit and instruments affects the note, but it can be most easily varied by the addition of resistance, capacity, or self-induction. Adding non-inductive resistance raises the pitch but weakens the sound. The addition of self-induction lowers the note, and the same effect is produced by shunting the telephone with a condenser. Variation of the distance between the telephone and microphone diaphragms alters the note; with the higher note increased distance gives a steadily rising pitch; while with the lower note the steady rise of pitch is broken by a sudden change in character. The author suggests the following explanation as probable: When the diaphragms are brought nearer, the current increases, but owing to lag the increase of current does not correspond with the movement of the microphone diaphragm. The telephone diaphragm apparently follows the current more or less accurately, and its air waves take an appreciable time to reach the microphone, resulting in an air lag as well as an electrical lag. The high note is given when the diaphragm of the telephone moves (at the appropriate lag) in the same direction as that of the microphone, and the low note when in the opposite direction. E. C. R.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1901.

GENERAL PHYSICS.

2322. *Thermal Deformation of a Balance.* **T. Middel.** (Ann. d. Physik, 6. 1. pp. 214–216, Aug., 1901.)—The author replies to Felgentraeger [see Abstract No. 1622 (1901)], and admits that the unequal expansion of the beam and knife-edges does alter the sensitiveness of Krigar-Menzel's balance, but that the unequal expansion of the rolled and cast brass must be added in order to explain the whole of the difference observed. E. E. F.

2323. *Form of Rifle Bullets.* **E. Lampe.** (Deutsch. Phys. Gesell., Verh. 3. 10. pp. 119–124, 1901.)—According to Newton's theory, the resistance experienced by a body in motion through a resisting medium is to be calculated on the assumption that the resistance on each element of surface is proportional to the area, and to the square of the cosine of the angle between the normal to the element and the direction of motion. The writer refers to the works of Kneser, Armanini and August (in which Newton's theory is not unconditionally accepted). He then discusses mathematically by Newton's method the case of a truncated right cone of given height and given radii of its flat surfaces, and compares the results with August's tables. It is found that the resistance calculated by August for his assumed practical form of bullet does not materially differ from that of a surface of least resistance having the same front. In conclusion, he refers to Müller-Breslau's calculations of the resistance to navigable balloons, which agree fairly with Newton's law, but are irreconcilable with other laws, *e.g.*, that of Lössel. S. H. B.

2324. *Clustering of Gravitational Matter.* **Kelvin.** (Nature, 64. pp. 626–629, Oct. 24, 1901. Paper read before the British Association.)—It is assumed in this discourse, as in the previous paper [see Abstract No. 2078 (1901)], that the Newtonian law of attraction between masses of gravitational matter, known to hold accurately for certain interplanetary spaces, holds also throughout infinite interstellar space. It is the only law of which we have definite knowledge, and therefore is assumed to be universal.

Ether, according to this discourse, is matter, but is not gravitational matter, and the reason is given that, if it were gravitational, we should be compelled to assume its infinite incompressibility, which to the author appears improbable.

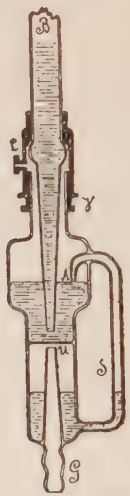
He considers it probable that there may be as much matter as a thousand million suns within a sphere of radius $3{\cdot}09 \times 10^{16}$ kilometres (that being the distance at which a star must be to have a parallax 0·001 of a second) because, given that they were uniformly distributed throughout such a spherical space, and at rest twenty-five millions of years ago, they would now have acquired, by their mutual attraction, some such velocities as the stars are now supposed to have.

Kelvin then compares the sunlight with that from the thousand million stars, supposing each star to have the same intrinsic brightness as the sun.

He works out the mathematical problem of the subsequent motion of a uniform sphere of matter of density ρ, given initially at rest, and discusses the question as to how this motion would be affected by ether.

If all the matter in the universe were, at a certain epoch, at rest, and more densely distributed in some regions than in others, there would be a tendency for the densities to become more unequal, solid bodies would ultimately form, and there would be collisions, giving rise, according to the author, to trains of waves in ether, carrying energy away to infinite space. The origin of meteoric stones is attributed to the cooling caused in this manner. S. H. B.

2325. *Laboratory Barometer with Automatic Zero Adjustment.* **B. Woringer.** (Zeitschr. Phys. Chem. 38. pp. 326–330, Sept. 17, 1901.)—The automatic zero adjustment of this instrument, shown in the figure, works as follows:—By means of a rubber bulb attached to the tube G, mercury is



driven up the tube S into the vessel V until the surface of the liquid in V covers the point A. On releasing the pressure, mercury flows back again into the lower vessel until the opening at A just touches the mercury in the upper vessel. In this way the barometer tube B has a constant zero level. The author also gives a description of a vernier for reading barometers. T. H. P.

2326. *Theory of Elasticity.* **G. Bakker.** (Journ. de Physique, 10. pp. 558–563, Sept., 1901.)—The theorem is established that the increase of volume of a body of any shape, under the exclusive action of external forces

applied to its surface, is proportional to the *virial* of these forces. This is then applied to the cases of a prism, a cylindrical shell, a spherical shell, a piezometer, and an electrified conductor. E. H. B.

2327. *Measurements of Gravity on the Italian Riviera.* **C. Aimonetti.** (Accad. Sci. Torino, Atti, 36. 13a. pp. 553–558, 1901.)—The author made measurements at Genoa, Savona, Albenga, and Sanremo. Details are given of the instruments used and the methods adopted. Comparing his results with values calculated from Helmert's formula—

$$G_0 = 9{\cdot}78046\,(1 + 0{\cdot}005302\sin^2\phi - 0{\cdot}000007\sin^2 2\phi)$$

the author finds the following differences: At Genoa — 0·00008; at Savona — 0·00055; at Albenga — 0·00029; at Sanremo + 0·00022. G. H. B.

2328. *Earthquake of April* 24, 1901. **L. Palazzo.** (Accad. Lincei, Atti, 10. pp. 351–354, 1901.)—An account is given of an earthquake, affecting Rome with considerable violence. Its origin was traced to a point at a depth of about half a kilometre under a sulphur spring at Cretone, and its cause to a subsidence of strata there. A. D.

2329. *Non-Pendular Apparatus in Seismometry.* **E. Oddone.** (N. Cimento, 1. pp. 195–201, 1901. Abstract from the Bull. Soc. Sism. Ital. 6, 1901.)—A description is given of apparatus for measuring both relative and absolute movement. It is of the nature of a hydraulic press, with one side of the large cylinder mobile and weighted: a shake alters the liquid pressure, and the displacement effect is magnified in the small cylinder, which is capillary and actuates a writing-point. The working is said to be satisfactory, and the instrument very sensitive. A. D.

2330. *Measurement of Atmospheric Pressure.* **G. Guglielmo.** (N. Cimento, 1. pp. 365–378, 1901. From R. Accad. dei Lincei, 10. series 5, No. 1.)—The author employs the principle of the areometer or cartesian diver for the measurement of atmospheric pressure and its variations. The advantage offered is that the ratio of glass to air may be so fixed as to eliminate temperature effects altogether, and the diver may be weighted so as to rise or sink at a certain pressure. By increasing the air space and the density of the liquid, the sensitiveness may be increased almost indefinitely. It is necessary, however, to prevent the absorption of the air by the liquid, and for this purpose the author either interposes a mercury column or a long capillary spiral tube. E. E. F.

REFERENCES.

2331. *Force Due to Continuous Impact.* **F. Slate.** (Phys. Rev. 12. pp. 363–365, June, 1901.)—The usual application of Newton's second law of motion is to cases in which the permanent factor is the mass, and the other factor, during any period, represents an aggregate of differential speed changes. With this is contrasted the case of a steady water-jet impinging on a plate. Here the permanent factor is change of speed, and the other factor represents an aggregate of differential masses. This case is discussed and the usual relation confirmed. E. H. B.

2332. *Apparatus for Illustrating Forced Vibrations.* **J. R. Benton.** (Phys. Rev. 12. pp. 377–378, June, 1901.)

2333. *Mercury Lifting Appliance.* **B. Woringer.** (Ann. d. Physik, 6. 1. pp. 211–213, Aug., 1901.)—The appliance described is for raising mercury automatically by means of a water vacuum-pump ; it is convenient when cleaning mercury by allowing it to drop through acid, as it can be arranged to keep the mercury in continual circulation without any attention. G. H. B.

2334. *Struts with Transverse Loads.* **H. E. Wimperis.** (Cambridge Phil. Soc., Proc. 11. pp. 191–199, Aug. 10, 1901.)—Some experiments on the collapse of struts, when subjected to a concentrated transverse load in addition to the longitudinal compression. H. R. C.

2335. *Microseismometrograph.* **G. Agamennone.** (Accad. Lincei, Atti, 10. pp. 291–299, 1901.)—The author completes his description of the three-component instrument [see Abstract No. 2405 (1900)] by an account of the arrangement for recording the vertical component, founded on Ewing's work of 1881 (Trans. Seism. Soc. Japan, vol. 3, p. 140). A. D.

2336. *Density of the Solar Nebula.* **A. S. Young.** (Astrophys. Journ. 13. pp. 338–343, June, 1901.)—The authoress attempts to find a satisfactory equation representing the conditions obtaining in the primary nebula from which the solar system has been evolved. Various methods are described involving several assumptions, but it is concluded that "it seems probable that the density of the solar nebula was irregular." C. P. B.

2337. *Formation of Meteorites, Comets, and Nebulæ.* **T. C. Chamberlin.** (Astrophys. Journ. 14. pp. 17–40, July, 1901.)—This paper consists of an elaborate extension of the discussion of "Roche's limit" to the formation of celestial bodies, many of the conclusions agreeing closely with the actual photographed forms of known objects. C. P. B.

2338. *Exploration of the Higher Atmosphere.* (Archiv Post Tele. 17. pp. 561–565, Sept., 1901. Abstract of a paper, read by **Assmann,** on the work of the Aeronautical Observatory of the Royal Meteorological Institute at Tegel, near Berlin.)—Unmanned balloons, kite or captive balloons (combined with the apparatus of Parseval and Siegsfeld, a bag, open at the lower end and not charged, to be inflated by the wind), and kites are employed. The paper also reproduces the police notices concerning the treatment of balloons or kites and their registering instruments when found. H. B.

2339. *Report on the Observatory Department of the National Physical Laboratory for the Year ending Dec.* 31, 1900. (Roy. Soc., Proc. 68. pp. 421–453, Sept. 12, 1901.)—This work is considered under the following headings : I. Magnetic Observations. II. Meteorological Observations. III. Seismological Observations. IV. Experiments and Researches. V. Verification of Instruments. VI. Rating of Watches and Chronometers. VII. Miscellaneous.

2340. *Objects having Peculiar Spectra.* **E. C. Pickering.** (Astrophys. Journ. 14. pp. 144–146, Sept., 1901. Harvard College Observatory Circular No. 60.)—This paper gives a list of stars having peculiar spectra, found by Mrs. Fleming from an examination of the Draper Memorial photographs, with notes on the nature of the peculiarities.

2341. *The Atomic Theory.* **A. W. Rücker.** (Electrician, 47. pp. 801–804, Sept. 13 ; and 839–842, Sept. 20, 1901.)—Presidential address delivered at Glasgow, Sept. 11, 1901.

LIGHT.

2342. *Proofs of Refractometer Formulæ.* **A. Cornu.** (Comptes Rendus, 133. pp. 463–469, Sept. 16, 1901.)—The author here gives the mathematical proofs of the formulæ contained in a preceding paper on the determination of the optical constants of biaxial crystals, by a method depending on total reflection from the face of the crystal, when it is placed in a more refracting medium. [See Abstract No. 1868 (1901).] The first group of formulæ are purely geometrical, and give the angles α, β, γ, which the normal to the crystal face makes with the three principal axes. By spherical trigonometry, triangles are obtained connecting the unknown angles α, β, γ with the observed azimuths of three planes of reflection, giving maximum or minimum values for the angle of total reflection. Difficulties connected with the uncertainty of observations at a maximum or minimum, and with ambiguities in solution of the triangles are discussed. The second group of formulæ involve the refractive indices. Their demonstration resolves itself mainly into a calculation of the direction cosines of various lines, with a view to determining the angles between them. A. E.

2343. *Visual Sensation.* **C. L. Morgan.** (Roy. Soc., Proc. 68. pp. 459–474, Sept. 12, 1901.)—This is a Croonian Lecture, in which the author gives an account of his studies in visual sensation. It is well known that a series of equal increments of stimulus does not produce a similar series of equal increments in sensation. This may be illustrated by means of a rotating disc. When the physical luminosity of a surface is the arithmetical mean between that of a white and a black surface, the brightness, or sensation-luminosity, is far removed from the arithmetical mean between that due to white and that produced by black. With a disc made up of successive rings shading off from black to white, effects of contrast come into play, but these can be allowed for. A series of rings may be obtained which do afford approximately equal steps from black to white, of which any intervening ring appears to be of an intensity which is the arithmetical mean between its neighbours on either side. This may be done by means of slit discs on Maxwell's method, giving sectors which slide over each other so as to alter the relative proportions of the white and black. First a mid-grey may be found, which appears to give a half-way sensation between black and white; then other greys, which appear to be arithmetical means between the mid-grey and black on the one hand, and on the other hand between the mid-grey and white. Thus, by a series of careful adjustments, rings may be obtained which enable the eye to pass from black to white by steps which are of approximately equal value for sensation. Using this scale or ladder from black to white, the black (a dull black surface coated with black enamel) may be termed the zero of an arbitrary scale, and may be assumed to be a very dark grey, and taken as the zero of stimulus, and also the zero of sensation. At the other end of the scale the white (white paper) affords an arbitrarily selected luminosity under given conditions of illumination, and may be called 100 per cent. of stimulus, corresponding to 100 per cent. of

sensation. The experimental results obtained, expressed in percentages, are as follows :—

Sensation	0	25	50	75	100
Stimulus	0	6·5	20	47	100

While the sensations are in arithmetical progression, there is at first sight no very definite series in the stimuli. But putting down the *increments* of sensation and of stimulus, the figures are :—

Sensation.....	0	+ 25	+ 25	+ 25	+ 25 = 100
Stimulus	0	+ 6·5	+ 13·5	+ 27	+ 53 = 100

Here the stimulus increments are nearly in geometrical progression, and, as a provisional and empirical generalisation, it may be said that equal increments of sensation require increments of stimulus in geometrical progression.

Hence other points may be interpolated between those obtained by observation, and through them a smoothed curve drawn. The author finds that, for his eye, the mid-point between black and white corresponds to 12 per cent. of white stimulus. When the illumination is reduced to one-half its original value the mid-sensation becomes 41·5 per cent., and requires 8 per cent. of stimulus. Hence, to produce a mid-sensation between the black and the reduced value of the white, an additional 2 per cent. of stimulus is required.

Experiments on colours shading off into black, and white shading evenly into colour, and also cases of the shading of one colour into another, were carried out, and these confirmed the previous result that equal increments of sensation require increments of stimulus in geometrical progression.

In conclusion, the author refers to the relation which the empirical scale of sensation may hold to an absolute scale based on certain assumptions.

J. J. S.

2344. *Negative After-Images and Colour Vision.* **S. Bidwell.** (Roy. Soc., Proc. 68. pp. 262–285, June 24, 1901. Abstract in Nature, 64. pp. 216–218, June 27, 1901.)—The paper deals with the "pulsative after-images" produced by a recurring series of short flashes, which were described by the author in a former communication (Roy. Soc. Proc. 61. p. 268 ; Nature, 56. p. 128), and which differ considerably from the ordinary negative after-images seen on a white ground after prolonged gazing at a coloured object. The present experiments were made with pure spectrum colours. A round colour patch is flashed on a screen for $\frac{1}{40}$ second, and then, in the same place, a patch of white light for $\frac{3}{40}$ second. Then, after a dark interval of $\frac{1}{10}$ second, the colour-patch is repeated, and so on in regular succession. A form of W. Abney's colour-patch apparatus is used, intermittency being secured by a rotating disc, with windows, placed in the paths of the beams. The true tint of the colour patch is not seen at all, but its approximate complementary. Thus, when the patch is really green, the appearance is that of a purple patch surrounded by an annulus of flickering white. The pulsative after-images of red, purple, and orange patches are all of nearly the same bluish-green tint, while those of yellow and blue are generally pink. If a complete spectrum be projected on a screen, the pulsative images of red and green are far more intense than those of yellow, blue and violet. If the white patch be replaced by an annulus of smaller diameter than the coloured patch, the annulus appears to be bordered on either edge by a narrow black ring,

showing that white light has the power of restraining the visual sense-organs adjacent to those upon which it actually falls from responding to the green stimulus.' It would seem to follow *a fortiori* that the sense organs directly acted on must be similarly incapacitated. In the formation of the pulsative image, then, it is not a case of the green sensation being produced for a moment, and then swamped by the more powerful one ; it never actually comes into existence at all. A possible explanation is that the latent period for a colour sensation is very much greater than for white, say $\frac{1}{40}$ second, as compared with, at most, $\frac{1}{300}$ second. Thus, if in a dark room, a green flash is admitted to the eye for $\frac{1}{40}$ second, it is not seen till the green ray which excited it has been shut off. What is actually perceived is, in fact, a positive after-image. But if a bright white surface is presented to the eye immediately after the green stimulus, the after-image formed will not be positive but negative. In some cases it is better to view the pulsative image directly with an eye-piece, instead of receiving it upon a screen. The following experiment proves that phenomena of simultaneous contrast are not always due to mental judgment. If a purple pulsative image is produced from a bright-green colour patch, the whole of a white-light field four times as wide as the colour patch appears to be purple. This cannot result from mental contrast with green, since no green at all is consciously perceived. Some account is given of another class of phenomena. If the image of a white object be suddenly formed on the retina after a period of darkness, it appears surrounded by a narrow red border. It is found that pulsative images of spectral red, orange, and yellow produce the red border, the effect stopping short at the beginning of the greenish yellow. Blue and green produce a blue-green border. Generally the experiments establish nothing decisively in favour of either Young's or Hering's theory, and some of them seem to indicate that neither theory is tenable in its present form. A. E.

2345. *Anomalous Dispersion of Cyanin.* **A. Pflüger.** (Phil. Mag. 2. pp. 317–318, Sept., 1901.)—A reply to passages in recent papers by Wood. [See Abstracts Nos. 661 (1899), 791 and 1636 (1901).] A strong absorption band was found by Wood in the ultra-violet, of which Pflüger's photographs show no trace. The latter attributes the discrepancy to difference of chemical constitution in the specimens of cyanin used. He defends his prisms (wrongly described as Wernicke's) against Wood's criticisms, and maintains that Wood's measurements are not really more accurate than his own. The principal difficulty lies, he says, not in making a prism with perfect enough faces, but in the broadening of the image of the slit in the region of the absorption-band, owing to the decline of the dispersion-curve and the narrowness of the transparent part of the prisms. A. E.

2346. *Colour Solutions for Orthochromatic Plates.* (Scientific American, 85. p. 84, Aug. 10, 1901.)—Different colour solutions, mostly of the eosine group, were tested to find their relative sensitising powers. The plates sensitised by them were exposed to red light. Erythrosene was found to have twice the sensitising power of any other solution tried. Directions for sensitising are given. G. H. B.

2347. *The Spectrum of Cyanogen.* **E. C. C. Baly** and **H. W. Syers.** (Phil. Mag. 2. pp. 386–391, Oct., 1901. Paper read before the Physical Society of London, June 28, 1901.)—Smithells pointed out [Abstract No. 1272 (1901)] the desirability of observing the vacuum-tube spectra of cyanogen, since if

the carbon spectra were absent it would support his theory that the "carbon-oxide" spectrum is due to CO_2 and the Swan spectrum to CO, while the line spectrum belongs to the element carbon. Baly, in 1893 (ibid. xxxv., 200), in attributing certain spectra to H and CO_2, had been criticised by Kayser (Handbuch d. Spectroscop., 198), from the general view that CO_2 had no spectrum. It was found, however, that in mixtures of H and CO the Swan spectrum was at once changed into that of "carbon-oxide," and that it could only be separately obtained with very pure CO, leading to the inference that the spectra were those of CO and CO_2 respectively. A very small quantity of CO_2 gives a very decided spectrum, and can easily mask that of CO, while CO itself is so readily changed into CO_2 that it shows none, or very little, of the Swan spectrum, but only that of "carbon-oxide." When perfectly pure CO, from formic acid and H_2SO_4, is used, and all gases are removed from the glass and electrodes by heating and exhaustion, the Swan spectrum only is obtained. Under certain circumstances CO deposits carbon, and the "carbon-oxide" spectrum then at once appears, a result which also occurs if a trace of oxygen be admitted, both facts strongly supporting Smithells' opinion. The authors purified cyanogen by freezing, and allowed it to slowly evaporate into the vacuum-tube, using an apparatus which is figured. On account of the discharge producing a brown coating of paracyanogen, it was necessary to examine the tube "end on." After repeatedly admitting and pumping out the gas, a very beautiful spectrum of pure cyanogen, differing from the flame-spectrum, was obtained. It showed a series of flutings through the red and yellow, wider than the nitrogen bands, and without the break in the orange. These experiments prove that the Swan spectrum is not produced by a carbon compound which does not contain oxygen; that it is only produced by carbon monoxide; and that the "carbon-oxide" spectrum belongs to carbon dioxide. The research was made in the Spectroscopic Laboratory of University College, London. S. R.

2348. *Phosphorescent Glow in Gases.* **J. B. B. Burke.** (Phil. Mag. 1. pp. 342–356, and 455–464, 1901.)—Between certain limits of pressure, which vary for different gases, a brilliant phosphorescence follows the passage of the ring discharge in an electrodeless vacuum-tube. This glow may last for one or two minutes, and takes place in the gas, not being an electrostatic effect on the glass. The after-glow is exhibited for air bulbs if the pressure is between 0·7 mm. and 0·02 mm., and is brightest at about 0·1 mm. In one of the experiments the external discharge takes place round a bulb at the end of a long tube, 5 cm. diam., connected with a McLeod gauge. When the discharge is produced in the bulb, the glow passes down the long tube at the rate of about 2 m. per sec., the rate being smaller for narrower tubes. It is "inferred that the phosphorescence consists of glowing particles or molecules which do not carry an electrical charge, which are not destroyed or broken up by an e.m.f. sufficiently small not to produce a discharge in the gas, and which are not created by the recombination of ions along the tube, but are particles or molecules that are produced in the bulb by the passage of the ring discharge and make their way down quite independently of the electrical condition of the tube." The phosphorescence of gases appears to be due to the presence of foreign bodies, and the presence of oxygen seems a necessary condition for the glow, although not in itself a sufficient one. Further experiments show that (1) "the glow conducts as it passes through the gas"; (2) "the destructive effect of sparks on the glow is due to kathode rays"; (3) "there is an analogy between the glow and thermoluminescence"; (4) "the phos-

phorescent particles appear to consist of large molecular groups formed by the spark, and which may continue in existence for some time (notwithstanding the bombardment from the molecules of the gas) in consequence of the repulsion which they must exert on molecules that approach them."

G. E. A.

2349. *Secondary Rays.* **E. Dorn.** (Archives Néerlandaises, 5. pp. 595–608, 1900.)—Sagnac has shown that certain of the rays given off when Röntgen rays fall on heavy metals are absorbed by a layer of air 0·1 mm. thick, thus exhibiting a similarity to the extreme ultra-violet rays photographed by V. Schumann. Dorn, by passing the rays from a powerful tube into an evacuated chamber, produces secondary rays on a tilted lead plate. These rays pass upwards through slits in lead plates to a photographic plate, and it is shown that they are absorbed by fluorite and quartz, but are transmitted easily by thin aluminium. The rays are not regularly reflected, and the existence of a diffuse tertiary radiation points to a connection with kathode or Röntgen rays. By using a magnet it was found that part of the secondary beam was deflected and part unaffected. The electrical screening was sufficient to prevent a direct production of kathode rays inside the apparatus, and it was also proved that there were no kathode rays in the direct beam from the tube. Curie and Sagnac have since verified that the deviable secondary rays are only produced by Röntgen rays impinging on heavy metals. From measurements made, the value 364 is found for Lenard's double integral, and the velocity of the deviated rays is calculated from the formula $v = \frac{e}{m} \cdot \frac{364}{s}$, where s is the deviation. Taking Lenard's and Simon's values for $\frac{e}{m}$, values of v are found which vary between $1{\cdot}8 \times 10^9$ and $8{\cdot}5 \times 10^9$ cm./sec. The high velocity of the negative particles is probably due to the violence of the impulses. G. E. A.

2350. *Uranium Radiation.* **H. Becquerel.** (International Physical Congress at Paris, Report, 3. pp. 47–78, 1900.)—The report gives a good summary of the present knowledge of the above subject. It treats of the photographic and electric methods of observation, and the use of a uranium sphere is mentioned as a new method of obtaining the potential of a point in space, the rate of fall of potential of the sphere when connected to a condenser of known capacity being expressed by $\frac{\partial V}{\partial t}\left(a + \frac{b}{V}\right) = -1$, where a and b are constants depending on the capacity of the system. Other effects, such as phosphorescence and magnetic and electrostatic deviation, are described. The report does not confine itself to the radiation from uranium.

G. E. A.

2351. *The Nature of Röntgen Rays.* **J. Semenow.** (Comptes Rendus, 133. pp. 217–219, July 22, 1901.)—In a bianodic tube with platinum antikathode, the antikathode emits Röntgen rays by both faces (anterior and posterior) in the same way, but the intensity of radiation from the anterior face is much the greater of the two. The antikathode only emits rays if it be electrically charged : if put to earth it emits none. The rays coming directly from the kathode have an intensity much inferior to that of the posterior antikathodic radiation, and are in this respect comparable to the radiations from the walls of the tube. Experiments are then described upon

the unipolar production of Röntgen rays. The three electrodes of a bianodic tube were connected together, and with either of the poles of a focus tube in action: the bianodic tube acted quite in its ordinary manner, but much more feebly, always provided that there was a Crookes tube in the secondary circuit of the induction coil. Any conductor in the neighbourhood of a Crookes tube becomes a source of "secondary" rays; and this induced radiation is more powerful the higher the charge on the conductor. Conclusions:—Röntgen rays represent the direction of propagation of electric vibrations through the ether, which vibrations are communicated to all bodies impinged upon; and when these bodies are insulated, and protected from loss by convection, they lose their charge by radiation. A. D.

2352. *Effect of Becquerel Rays on Air.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 2. pp. 590–593, July 6, 1901.)—Rutherford has found that air passed over thoria makes other substances upon which it impinges radio-active, particularly if they be negatively charged. The Becquerel rays, then artificially induced, may be recognised by their making the air conductive, through ionisation. The authors investigated as to whether air not passed over thoria or other analogous substances would produce the same effect to any extent. They find that it does so in presence of a negative charge, and that the air probably contains a radio-active gas. Wherever there is a steep atmospheric potential-gradient leading to a dense negative charge on the earth (*e.g.*, on mountain peaks) there must be an increase in the conductivity of the air. Certain anomalies in electrical dispersion in closed rooms, when bodies are introduced which have been long exposed to electrified air, now find their explanation in the conclusion that natural atmospheric air in contact with negatively charged bodies of any kind makes these bodies radio-active.

A. D.

REFERENCE.

2353. *Röntgenised Air.* **E. Villari.** (Accad. Lincei, Atti, 9. pp. 61–72, 1900.) —The matter of this paper is dealt with in Abstract No. 1643 (1901). A. D.

HEAT.

2354. *Thermal Properties of Isopentane and Normal Pentane.* **J. Rose-Innes** and **S. Young.** (Phil. Mag. 2. pp. 208–210, Aug., 1901. Paper read before the Phys. Soc. of London, May 10, 1901.)—If "the departure from Boyle's law" be defined as the value of $RT-pv$ for the particular volume and temperature in question, the departure for isopentane appears, within the limits of experimental error, to bear a constant ratio to the departure for normal pentane at the same volume and temperature. By calculating the values of pv for isopentane from the corresponding values for normal pentane, and graphically comparing them with those determined by direct experiment, the authors show that by far the greater part of the difference in the behaviour of these bodies can be attributed to the action of the above law.

W. E. T.

2355. *Expansion of Glass and Porcelain at High Temperatures.* **L. Holborn** and **E. Grüneisen.** (Ann. d. Physik, 6. 1. pp. 136–145, Aug., 1901.)—This paper forms a continuation of a research on the expansion of hard bodies [see Abstract No. 810 (1901)]. Glass and porcelain present greater difficulties than metals, for in the first place they have smaller coefficients of expansion, and in the second place their conductivity is so small that the temperature is not easily equalised.

In the work on Berlin porcelain the authors used two specimens, one rectangular and the other cruciform in section. Tables are given for all the specimens tried.

It was found that quadratic equations of the following form represent the relation between the change in length and the temperature between 0° and 625° :—

$$\lambda = \{3027t + 1{\cdot}177t^2\}\,10^{-9}$$

and—

$$\lambda' = \{3188t + 0{\cdot}936t^2\}\,10^{-9},$$

the temperature being reckoned in the former equation in degrees, and in the latter in microvolts, on a thermoelectric system.

In working on glass, rods and tubes were used. The results were the same in form as for porcelain, being—

$$\lambda_1 = \{5814t + 0{\cdot}804t^2\}\,10^{-9}$$

and—

$$\lambda_2 = \{5852t + 0{\cdot}959t^2\}\,10^{-9}.$$

The former equation refers to tubes and the latter to rods. P. E. S.

2356. *Radiation of Black Bodies.* **O. Lummer** and **E. Pringsheim.** (Ann. d. Physik, 6. 1. pp. 192–210, Aug., 1901.)—This paper consists of a historical treatment of the experimental results hitherto obtained in this connection, of a reply to Paschen's criticism on the work of the authors, and of a critical review of Paschen's work. They come to the conclusion that Paschen's latest work cannot be regarded as establishing the validity of Planck's equation. At the same time it nearly represents the truth, and it has

the advantage over the empirical equation of the authors [see Abstract No. 870 (1901)] of reducing to Wien's equation in the limit for small values of λT. W. E. T.

2357. *Mechanical Equivalent of Heat.* **H. T. Barnes.** (Electrician, 45. p. 969, 1900. Paper read before the Royal Society.)—A determination of the mechanical equivalent of heat was made by imparting electrical energy to a constant stream of water, so as to give a steady difference of temperature at its ends. In terms of the thermal unit at 16° C., the specific heat of water was found to be 1·00530 at 5° C., 0·99735 at 40° C., and 1·00870 at 95° C., with a minimum at 37·5°, and the resulting mechanical equivalent of heat is equal to 4·18876 joules—a result which is about 0·132 per cent. higher than those of Reynolds and Moorby by direct mechanical means [see also Abstract No. 1879 (1899)]. The difference is ascribed to the e.m.f. of the Clark cell, to which the electrical measurements were referred. The actual cell was not considered wrong in itself, but if the e.m.f. of the Clark cell is assumed to be 1·43325 volts instead of 1·4342, the results are in agreement with those of Rowland. W. R. C.

2358. *Dissipation of Heat in a Thick Wall with a Radiating Face.* **J. Boussinesq.** (Comptes Rendus, 133. pp. 497–502, Sept. 30, 1901.)—The method of a former note [see Abstract No. 2012, 1900] is here extended to the general case wherein the initial temperatures are given by $f(x, y, z)$ instead of $f(x)$.

In the particular case where $f(x, y, z)$ is of the form $\chi(x) \exp(-y^2/b^2 - z^2/c^2)$, the isothermal surface for temperature u at time t is of the form—

$$y^2/(b^2 + 4a^2t) + z^2/(c^2 + 4a^2t) = \psi(x, t, u),$$

so that its trace on any plane parallel to the face is an ellipse which becomes more and more circular as the time goes on. R. E. B.

2359. *Construction of Entropy Diagrams from Steam-engine Indicator Diagrams.* **G. Wilson** and **H. Noble.** (Manchester Lit. and Phil. Soc., Mem. 45. 10. pp. 1–12, 1901.)—The indicator cards for all the cylinders of a compound engine should be referred to *unit mass* of mixed steam and water; the diagrams are then to be *reduced* by subtraction of the volumes of the clearance steam, and finally converted into entropy diagrams by Boulvin's graphic method. The reduction is made by Osborne Reynolds' method, with the assumptions, that during expansion the clearance steam follows the same law as the rest of the steam in the cylinder, and that the steam is dry at the beginning of compression. There is uncertainty as to the behaviour of the clearance steam at pressures below that corresponding to release, but this does not affect the important parts of the diagrams. R. E. B.

REFERENCE.

2360. *Possible Attainment of Absolute Zero Temperature.* **G. Martin.** (Chem News, 84. p. 73, Aug. 16, 1901.) R. E. B.

SOUND.

2361. *Stability of Sound Vibrations.* **C. Barus.** (Science, 14. pp. 403–405, Sept. 13, 1901.)—The experiments here described are intended to show the effect of the damping upon the pitch of a note; and to exhibit the conditions of stability of a system formed by an organ-pipe and a resonator. The apparatus consists of an open organ-pipe giving the note c'' and a cylindrical resonator which will give notes varying from b' to e'' according to the intensity of the blowing. The resonator is placed so that its axis is perpendicular to the organ-pipe, and the slit of the pipe is towards, and on the same level as, the resonator. When the resonator is gradually moved towards the pipe, the following phenomena are observed:—With the aperture of the resonator towards the pipe, the note rises to d'' at a distance 1·1 cm. For smaller distances the note returns to the original c''. For larger distances (1·7 to 1·5) destructive interference occurs. If the closed end of the resonator be towards the pipe, a flattening of the note occurs. Like effects are produced if the resonator be approached to the top of the pipe instead of to the slit. Explanation is found in the damping term of the expression for the period of vibrations of a system under friction, and having one degree of freedom. The open end of the resonator diminishes the damping to such an extent that the pitch is raised. The closed end increases the damping with contrary effect. A hysteresis phenomenon is also described. With the same arrangement as before, let the resonator be made to approach gradually, and then be withdrawn. Within the region 2·8 and 2·2 cm., the note is c'' on the forward journey and d'' on the return. J. W. P.

2362. *Behaviour of Small Closed Cylinders in Organ-pipes.* **B. Davis.** (Amer. Journ. Sci. 12. pp. 185–189, Sept., 1901.)—When a number of small gelatine capsules are placed at the centre of an organ-pipe, and the first overtone is sounded strongly, the capsules arrange themselves in rows across the pipe, as if there were an attraction at their ends in a direction perpendicular to the vibration and a repulsion at their sides parallel to the vibration. The distance between the rows in relation to the number of cylinders, size of cylinders, and amplitude of vibration is investigated. A stopped organ-pipe is used, and, to observe the effect, it has one of its walls replaced by a glass plate. At the node nearest the mouth a rubber diaphragm is placed, and the region observed extends from this to the stopped end. The amplitude of vibration is measured by the torsion balance referred to in Abstract No. 2132 (1901). It is found that the distance between the rows (1) decreases slightly with increase of amplitude; (2) decreases as the number of rows increases. This latter effect is more marked with the larger cylinders. An explanation based upon sound shadows is given, and several sets of illustrative tables are appended. J. W. P.

2363. *Location of Nodes and Loops.* **B. Davis.** (Amer. Journ. Sci. 12. pp. 263–264, Oct., 1901.)—By means of the rotating mill described in Abstracts Nos. 88 and 2132 (1901), the positions of loops and nodes can be found in cases where stationary waves exist, and the decrease of intensity with distance can be accurately measured in open spaces. The mill is mounted in the

mouth of an ordinary resonator, so that the plane of rotation is parallel to the mouth. An organ-pipe of considerable power is blown, and the resonator (which is in tune with it) is carried to different parts of the room. The rate of rotation of the mill indicates the intensities at the various points. Experiments made with a long rubber pipe gave 60 feet as the distance at which the mill just ceased to rotate; but, by more delicate apparatus, this could probably be much increased. J. W. P.

2364. *Photographophone.* **E. Ruhmer.** (Ann. d. Physik, 5. 4. pp. 803–810, July, 1901.)—The author gives photographs, on a moving plate, of a steady direct-current arc, of a hissing direct-current arc, of an intermittent arc, of an arc blown out by electromagnets and rekindling itself (with a whistling sound), of the same with longer arc and a rattling sound, with an intermittent current superposed on the direct current, with whistling into a microphone alongside the lamp current, and with the vowel A superposed on the main direct current in the same way. These led to the construction of apparatus which is described, in which telephonic variations affect a lamp-current, and the light presents corresponding variations. This varying light is received by a cylindrical lens, which projects it upon an extremely narrow strip of photographic film rolled past the lens. As the film passes the lens, such strips, contiguous and parallel to one another, are successively and varyingly acted upon, as appears upon development. Then the film is run at an equal rate between the same arc and cylindrical lens on the one hand and a selenium cell on the other. A telephone connected with the selenium cell reproduces the original sound or speech with great accuracy and very loudly. A. D.

2365. *Speaking Arcs.* **P. Janet.** (Soc. Int. Élect., Bull. 1. pp. 371–373, July, 1901.)—The paper contains particulars of the arrangement for using arcs as microphone receivers and also as telephone transmitters employed by C. Léonard, as being found to give the best results. A. D.

REFERENCE.

2366. *Resonators.* **V. Dvořák.** (Phys. Zeitschr. 2. pp. 490–492, 1901.)—An account of experiments undertaken to investigate the effect called the "acoustic repulsion" of resonators. The influence of the form and magnitude of the mouthpiece upon the action of resonators was also investigated. J. J. S.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

2367. *Coefficient of Self-Induction of a Ring of Rectangular Section.* **A. Garbasso.** (N. Cimento, 2. pp. 97–103, Aug., 1901.)—Referring to his paper on Maxwell's function T_{me} [see Abstract No. 1914 (1901)] the writer says that the formulæ were there developed on the hypothesis of the current being uniformly distributed throughout the section of the ring discussed in that memoir. In the present note he gives mathematical calculations of the coefficient of self-induction of the ring, which cannot be usefully set out in abstract. S. H. B.

2368. *Electromagnetic Fields.* **A. Righi.** (N. Cimento, 2. pp. 104–121, Aug., 1901. Abstract of paper read before the R. Accad. Sci. dell' Instituto di Bologna, Feb. 24, 1901.)—In Hertz's system there is a "characteristic vector," whose components, denoted by Π_x, Π_y, Π_z, each satisfy the differential equation—

$$\Delta\Pi = A^2 . \frac{d^2\Pi}{dt^2},$$

1/A being the velocity of light in free ether. The components, X, Y, Z, of electromotive force are then deduced from it in the form—

$$X = \frac{\partial}{\partial z}\left(\frac{\partial \Pi_x}{\partial z} - \frac{\partial \Pi_z}{\partial x}\right) - \frac{\partial}{\partial y}\left(\frac{\partial \Pi_y}{\partial x} - \frac{\partial \Pi_x}{\partial y}\right), \quad \ldots\ldots\ldots\ldots (1)$$

with corresponding expressions for X and Y. And L, M, N, the components of magnetic force are deduced in the form—

$$L = A\frac{\partial}{\partial t}\left(\frac{\partial \Pi_z}{\partial y} - \frac{\partial \Pi_y}{\partial z}\right), \quad \ldots\ldots\ldots\ldots (2)$$

with corresponding expressions for M and N.

By the symmetry of Hertz's equation, there corresponds another vector, whose components Π'_x, Π'_y, Π'_z have the converse property, so that—

$$X = A\frac{\partial}{\partial t}\left(\frac{\partial \Pi'_y}{\partial z} - \frac{\partial \Pi'_z}{\partial y}\right), \quad \ldots\ldots\ldots\ldots (3)$$

$$L = \frac{\partial}{\partial z}\left(\frac{\partial \Pi'_x}{\partial z} - \frac{\partial \Pi'_z}{\partial x}\right) - \frac{\partial}{\partial y}\left(\frac{\partial \Pi'_y}{\partial x} - \frac{\partial \Pi'_z}{\partial y}\right). \quad \ldots\ldots\ldots\ldots (4)$$

The relation between this second vector and Maxwell's vector potential is pointed out in a note. Also $\frac{\partial \Pi_z}{\partial y} - \frac{\partial \Pi_y}{\partial z}$ &c., are connected with $\frac{\partial \Pi'_y}{\partial z} - \frac{\partial \Pi'_z}{\partial y}$ &c. by the same relation as those which connect the magnetic with the electric force.

The writer applies the theory to certain cases of electric charges or poles in motion, namely (1) a simple electric dipol or vibrator, (2) the circular vibration of a dipol, (3) the vibrations of an ion.

He further considers the electromagnetic field produced (1) by the uniform

rectilinear motion of an electric charge; (2) by an electric particle in motion in any manner, but with small velocity; (3) by a system of electric charges or electrified lines and planes; (4) by a magnetic lamina in its own plane. He concludes with the remark that the conditions assumed in the last examples are approximately realised in experiments for proving the existence of magnetic force due to electric convection, or in experiments which he suggests to prove the existence of electric force due to magnetic convection. S. H. B.

DISCHARGE AND OSCILLATIONS.

2369. *Discharge-Current from a Surface of Large Curvature.* **J. E. Almy.** (Amer. Journ. Sci. 12. pp. 175–179, Sept., 1901.)—The author studies the discharge from a fine platinum wire of small diameter to a concentric circular cylinder. The wire is stretched along the axis of an insulated brass cylinder, whose ends are blocked by cakes of paraffin wax. By tubes passing through these stoppers, air or other gas can be drawn through the apparatus and different pressures can be obtained. When the same body of air is kept in the apparatus there is a decrease of capacity to carry on the discharge after it has been used for some time, so that in experiments with air a fresh supply of dried gas was continuously drawn through the apparatus. The author finds that the current discharging from the fine wire to the surrounding cylinder is given by the equation—

$$C = \frac{L}{r^3} aV (V - b),$$

where C denotes discharge current; V, potential difference between wire and cylinder; L, length of discharge wire; r, radius of cylinder; b, minimum potential necessary to produce a measurable discharge; a, a constant depending upon the size of the wire, the discharging gas, and the sign of the discharge.

For a given apparatus the variation of the discharge current with the pressure of the gas does not seem capable of being expressed in a simple formula. W. C. H.

2370. *Potential Difference and Damping of Oscillatory Sparks.* **F. Beaulard.** (Comptes Rendus, 133. pp. 336–338, Aug. 5, 1901.)—A minimum value of the damping coefficient is found for a spark length of 6 mm. J. E.-M.

2371. *Action of Light on Sparking Distance.* **A. Garbasso.** (N. Cimento, 2. pp. 15–19, July, 1901.)—With a given sparking distance, such that the sparks occur somewhat infrequently, the frequency will be, say, 24 per 30 sec. in sunshine and only 8·8 in the dark. The effect of sunlight persists for some time. The effect does not appear to be due to ultra-violet radiations, but to heating of the terminals. A. D.

2372. *Curves Produced by Point-discharges.* **R. H. Weber.** (Ann. d. Physik, 6. 1. pp. 96–103, Aug., 1901.)—The figures obtained by de Heen [see Abstract No. 99 (1901)] on holding an electrified resin-slab above the flame of a Bunsen burner, and dusting it with sulphur, can also be produced by means of point-discharges. The discharge from a point to a conductor appears to consist of two parts—of a visible part, which is most marked when the point is positively charged, and which is perhaps due to metallic

particles; and an invisible part, which can be rendered visible by interposing a piece of silk between the point and the conductor, is independent of the sign of the charge on the point, and is perhaps due to particles of air. If several points are discharging near together, each has a "discharge-field" which is very sharply defined. The shape of these fields can be reproduced by inserting a piece of "bromide paper" between the silk and the conductor. The field for a single point is more or less conical and gives a circular figure, but where two fields meet each becomes flattened, and in the photograph the boundaries are marked by lines which are quite straight in the centre of the figure, but broaden out at the open ends into hyperbolic forms. The general appearance of the figures is in many cases like that of a honeycomb. These figures are identical with those produced on dusting sulphur over a slab which has been exposed to the discharge from several points, the dark lines of the photograph corresponding with the streaks of sulphur on the slab.

The invisible discharge appears to consist of material particles, since the boundary line separating two discharge fields can be blown aside by a current of air. From the extent of the displacement the velocity of the particles forming the discharge was found in two experiments to be 9·8 and 12·1 metres per second. T. M. L.

2373. *Radio-activity.* **P. de Heen.** (Revue Scientif. 16. pp. 161–170, Aug. 10, 1901.)—Almost all foci of disturbance of the ether (flames, brush discharges, hot bodies, electric sparks, radio-active substances, &c.) produce an emanation comparable to that of a Crookes tube; and when this reaches a surface the action is as if the emanation were a fluid, or produced a fluid, distributed on the surface impinged upon, just as liquid would be by a jet of elastic liquid. It is as if these foci emitted ether, which on encountering matter of sufficiently small density, carried it with it mechanically. A new method of detecting the effect of the emanation upon a surface is furnished by the use of a thick card coated on both sides with colophane to which a little white wax has been added. This is first electrified by rubbing it in all directions and then exposed to the actions under study. On dusting it afterwards with sulphur, figures are developed which show the distribution of the charge on this plate. The charge has been driven into positions the same as those into which liquid would have been heaped up by a jet, or by a number of jets, as the case may be. A long series of very curious experiments of this order is described under the influence of flames, brush discharges, sparks, radio-active substances, superficial chemical activity, surfaces modified by the impact of light, Röntgen rays, and incandescent bodies. In the propagation of the emissions referred to there is a logarithmic law analogous to that of the conduction of heat, but the phenomena bear no close relation to diffusion. There seems to be an analogy to heat, in so far that we have to do both with conduction and radiation, but not with radiation originating in oscillation; rather an emission ranging from electrolysis (matter) through kathode and other rays to Röntgen rays (ether); and ionisation has to do, not with atoms, but with sub-atoms. A. D.

2374. *Decrement of Electrical Oscillations.* **A. F. Sundell** and **H. Tallqvist.** (Ann. d. Physik, 4. 1. pp. 72–98, 1901.)—The decrement observed in oscillations which arise on charging a condenser not agreeing with the calculated value, the paper treats of the causes of disagreement, and the corrections necessary for an accurate determination of the decrement.

For a circuit of resistance R, containing a battery and a coil of self-induction L, and connecting the coatings of a condenser of capacity C, an equation is found in which terms are introduced for the insulation resistances r and r' of condenser and coil. The capacity is next assumed to be variable, and the special case where the capacity alters uniformly with time is taken, and the equation of charging altered to suit this condition. The capacity variation is shown to have no effect on T, the period of oscillation, and the expression for the decrement shows that by uniform change of capacity the logarithmic decrement, $\lambda = \frac{\pi}{2} R\sqrt{\frac{C}{L}}$, increases by the amount $\pi h\sqrt{\frac{L}{C}}$, where h is the change of capacity per sec. The calculation of the decrement from a curve of charging is given *in extenso* for a case in which C = 1·0119 microfarad, L = 0·5933 henry, and R = 3·191 ohms, the experimental data having been collected by Tallqvist in 1896 (Wied. Ann., 1897). A table is given with twenty scale readings corresponding to successive minimum and maximum charges while the condenser was being charged, and from these the mean normal charges are calculated and corrected by a graphic method. This mean normal charge increases with the time. The determination of the damping factor is next considered, and the logarithmic decrement is corrected, first for the capacity increase, and second for the full capacity and the corresponding normal charge. The quantity $\gamma = \lambda \times 0{\cdot}43429$ being chosen for convenience of calculation, the table of corrected decrements (γ) shows a variation between the values 0·02040 and 0·02265, which is put down to experimental error. Instead of taking the arithmetic mean of the decrements, a new table is made up from the values of the extreme charges M_0, M_1, M_2, &c. These are dealt with in pairs, *e.g.*, $M_1 - M_0$ and $M_{19} - M_{20}$, $M_1 - M_2$ and $M_{19} - M_{18}$, and so on. The next column contains logarithms of these quantities, the next is a column of differences, and the fourth contains the means of successive differences. These mean values are corrected, and the reduced values so obtained are 18, 16 . . . 2 times γ, from which nine values of γ are obtained, the mean of which is given by $\gamma = 0{\cdot}02128 \pm 4{\cdot}3$. Another method, in which the capacity is taken as oscillatory with the charges, gives $\gamma = 0{\cdot}02141 \pm 4{\cdot}2$.

By removing the coil, curves of charging were obtained which exhibited the change of capacity with time. Although the capacity only reaches its full value after about 2 seconds' charging, the instantaneous charge after a very short time differs from the maximum value merely by a few tenths per cent.

The expression $\gamma = a + bR$ is given as the relation between the decrement and the resistance of the circuit, and the values of the constants a and b may be found from those of γ and R. Their theoretical values are—

$$a = M\frac{\pi}{2}\sqrt{\frac{L}{C}}\left(\frac{1}{r} + \frac{1}{r'}\right), \quad b = M\frac{\pi}{2}\sqrt{\frac{C}{L}},$$

M being 0·43429. The value of $\frac{1}{r} + \frac{1}{r'}$ remains practically constant while r is varied; $\frac{1}{r}$ is therefore negligible, and the experimentally found value of a thus gives a means of measuring the insulation resistance of an inductive coil. The method may also be employed to determine the conductivity of feeble conductors. With regard to the coefficient b, experiment and theory agree. Its value found by experiment may therefore be used in conjunction with the formula $T = 2\pi\sqrt{LC}$ to determine inductances and capacities. G. E. A.

2375. *Radiation of Ions from Wire Carrying Oscillatory Current.* **O. W. Richardson.** (Cambridge Phil. Soc., Proc. 11. pp. 168–178, Aug. 10, 1901.)—With a period of 14×10^{-8} sec. and a current density at the surface of $1{\cdot}3 \times 10^{6}$ amperes per sq. cm., no ionic radiation was detected. J. E.-M.

2376. *Transmission of Hertzian Waves through Liquids.* **C. Nordmann.** (Comptes Rendus, 133. pp. 339–341, Aug. 5, 1901.)—Experiments on dilute sulphuric acid, saturated solution of common salt, normal solution of potassium chloride, and solution of sulphate of magnesium at its maximum conductivity show that the transparency for the waves employed varies in the same sense as, but more rapidly than, the resistances. J. E.-M.

2377. *Coherers.* **T. Tommasina.** (Archives des Sciences, 11. pp. 557–577, 1901. Communicated to the Physical and Natural History Society of Geneva, April 4, 1901.)—The author maintains the truth of his theory of coherence as against Bose's theory of molecular distorsion, and describes a number of recent experiments in confirmation. He has succeeded in forming visible chains of particles suspended in petroleum between two electrodes. Some of the particles were dielectric, others metallic. The dielectric particles formed into chains first, and as the field increased in strength the metallic particles followed suit, being welded together eventually by minute sparks. Spontaneous decoherence is due, according to the author's view, to the interposition of non-conducting particles between the conducting particles. E. E. F.

2378. *Experiments on Filings Coherers.* **W. H. Eccles.** (Electrician, 47. pp. 682–685, Aug. 23, and 715–717, Aug. 30, 1901.)—The experiments were commenced with the object of revising what was known respecting the relative influences of oscillatory and of steady p.d.'s in promoting coherence in filings coherers. Several eminent authorities hold that the electrical surgings set up in the coherer circuit on the sudden establishment of a connection with a source of e.m.f.—as by any ordinary contact device used in conjunction with a battery—play an important part in the production of coherence. The precise function fulfilled by the electrical surgings has not been exactly outlined, but is imagined to consist in a modifying of the mechanical arrangement of the particles. There has been much conflict of opinion with regard to various points, such as the relative sensitiveness of coherers made with filings of different metals. The confusion appears to have arisen out of the great complexity of the numerous conditions which influence the mechanical and electrical behaviour of filings in a coherer—the phenomenon of pure coherence being, in all probability, greatly disguised and complicated by the preliminary and purely mechanical actions of the particles. If oscillatory discharges are proved to be necessary for efficient coherence, then the effect, on the movements, of displacement currents in the dielectric must be taken into account; while if, on the contrary, steady e.m.f.'s are shown to be sufficient, then other electro-mechanical connections must be proposed.

The author submitted coherers to e.m.f.'s supplied by a copper-sulphate solution potentiometer, avoiding any abruptness in the changes of p.d. The results removed all doubts as to the possibility of coherence by the application of absolutely non-oscillatory e.m.f.'s, and showed that any electrical surgings produced by sudden connection with the source of e.m.f. had little or no influence in compelling coherence beyond that which their maximum

voltage gives them. Apparently, then, coherence is an effect caused merely by p.d. It should be observed, however, that it is always possible, even when the applied p.d. increases slowly and continuously, that electrical surgings may be created by the first small discharge which takes place through the coherer along that line of particles which happens at the moment to offer the least resistance. Experiments with six coherers of medium sensitiveness showed that their cohering voltage lay between 1 and 4 volts. Unfortunately the values obtained were irregular, both when mechanical disturbance was avoided as far as possible, and when an uniform degree of mechanical disturbance was applied by a vibrating bell-trembler.

Surprisingly regular results can, however, be obtained as follows: The hammer of a trembler is allowed to strike uninterruptedly the coherer under examination (about fifty vibrations per sec.). During each quiescent stage between the blows coherence takes place, and a current passes through the galvanometer. Decoherence follows immediately, and is succeeded by another coherence, and so on. The galvanometer integrates the pulsating currents traversing it, and gives their mean value. Each movement of the jockey along the potentiometer wire is followed by an increase of deflection. A decided change occurs in the conductivity of the coherer at voltages much lower than the critical voltages obtained by previous methods. Plotting the results obtained, with volts as abscissæ and micro-amperes as ordinates, the sensitiveness of a coherer can be judged by the position and form of its characteristic curve. The occurrence of rapid coherence is indicated by convexity towards the lines of e.m.f. With all the coherers examined (except those known to be remarkably non-sensitive) some curvature is observed under comparatively small e.m.f.'s. As the applied e.m.f. increases, the current increases gradually—never suddenly. After a certain increase, the relation between current and e.m.f. becomes approximately linear. There is complete correspondence between the sensitiveness of a coherer to electromagnetic radiation and the position on the chart of the characteristic curve obtained by the above method. Electrical surgings, such as are no doubt produced in any circuit to which an e.m.f. is abruptly applied, have no effect —as surgings—in producing coherence. The phenomenon of coherence, as Branly and others have always insisted, is an effect of e.m.f. merely. Coherence is a continuous phenomenon, and there can be no true "critical voltage." The author considers that the common expressions "the impinging of waves" and "the incidence of radiation in a coherer" might with advantage be deleted from our phraseology. He gives a kinetic theory of the filings coherer, which makes the typical coherer consist of filings free to move throughout the space of a narrow crevasse, bounded at its ends by plane conducting surfaces. D. E. J.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2379. *Resistance of Bismuth in a Magnetic Field.* **G. C. Simpson.** (Phil. Mag. 2. pp. 300–311, Sept., 1901.)—Lenard found that the resistance of bismuth in a magnetic field was different to continuous and to alternating currents; the resistance, too, was found to vary with the frequency; but the results obtained by different experimenters, as to the way in which it varies, do not agree. The author's experiments were undertaken with a view to determining the variation of resistance with frequency.

Any change in the resistance of the bismuth may be regarded as an e.m.f. set up in the bismuth, and is named by the author the "bismuth e.m.f." If the

change is really a change in the resistance, this bismuth e.m.f. will be opposite in phase to, and of the same wave-form as, the current causing it. If there be anything of the nature of self-induction or capacity in the bismuth, the phase of the bismuth e.m.f. will be displaced, and possibly the wave-form of the current altered. The methods followed are fully described, and curves and table of the results given. It was found that the bismuth e.m.f. lagged behind the current producing it, by an angle α, where $\tan\alpha = 1{\cdot}13 + \frac{13{\cdot}2}{n}$ and n is the frequency between values of 10 and 60 $\sim$, and that its value was proportional to $0{\cdot}0035 + 0{\cdot}00039n$. G. H. B.

2380. *Electric Conduction in Metals.* **E. Riecke.** (Phys. Zeitschr. 2. p. 639, Aug. 3, 1901.)—A conductor was made up of an aluminium cylinder placed longitudinally between two copper cylinders, all put under heavy pressure, and a current was passed through for twelve months. There was no appreciable alteration in the weights of the three cylinders. This would indicate that metallic ions do not play any part in metallic conduction, as the author had anticipated they would do (Ann. Phys. Chem., 1898). A. D.

2381. *Temperature Gradient in a Wire heated by an Electric Current.* **A. Corazzol.** (Elettricità, Milan, 20. pp. 584–585, Sept. 14, 1901.)—The author derives an expression giving the temperature at any point of the diameter of a long cylindrical conductor heated by a current. The temperature gradient is a parabola, whose axis coincides with the axis of the conductor. He also treats the general case, where the conductor is not a cylinder. G. H. B.

2382. *Conductivity of Liquid Dielectrics.* **E. v. Schweidler.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 964–973, 1900, and Ann. d. Physik, 5. 2. pp. 483–486, May 29, 1901.)—A current is passed through pure commercial toluol between two horizontal parallel plates, and measured by a delicate high-resistance galvanometer, a known e.m.f. being applied. Results are given for e.m.f.'s varying from 5 to 300 volts, showing that the current decreases with time, first rapidly, and afterwards slowly. This decrease is ascribed to a fall in the conductivity, or fatigue of the dielectric, since little or no polarisation is observed. If the e.m.f. be removed for a time and again applied, the current is greater than when it was cut off. This is explained as a recovery from the fatigue, the recovery being greater the longer the period of rest :—

Interval of Rest. Min.	Increase of Current. Per cent.
0·5	4·3
1	7·5
2	12·7
4	18
5	27

Hertz had explained the above increase as due to the combination of the main with the residual current. If the current be reversed after being on for some time it increases temporarily. The fatigue and recovery after rest and on reversal are all more marked with higher e.m.f.'s. An experiment is carried out to show that there is a strong analogy between a liquid dielectric and an ionised gas. A current at 300 volts is passed through toluol by means of two zinc plates 24 mm. apart, and the potentials at various points between

the plates are measured by means of an immersed Pt wire, the distance of which from the electrodes could be accurately measured. The potential gradient is shown to be greatest near the electrodes, indicating the presence near the anode of free negative, and near the kathode of free positive charges. In the second paper the variation of e.m.f. with current is given, as shown in the following table, the current being measured after having reached a constant value. Petroleum was the liquid employed.

E.M.F.	Current.	E.M.F.	Current.
Volts.	10^{-10} Amps.	Volts.	10^{-10} Amps.
5	8	100	91
10	17	300	218
15	21	400	276
50	55		

Koller's result that the current increases more slowly than the e.m.f. is thus verified. The addition of small quantities of impurities, soluble or insoluble, made no great change in the dielectric conductivity, whereas the increase in that of benzol and toluol exposed for days to the air, the rapid increase when the surface was breathed on, and a reduction of the conductivity of benzol to one-fifth its former value after distillation over sodium, show that the amount of water present has a great influence on the conductivity, if it be not its cause. Warburg's view that the deviation of badly conducting substances from Ohm's law is due to the presence of small quantities of better conducting electrolytes is supported by these experiments. The following values of conductivity were found :—

Substance.	K in Ohm^{-1} $cm.^{-1}$.	Substance.	K in Ohm^{-1} $cm.^{-1}$.
Toluol	6×10^{-13}	Petroleum	3×10^{-13}
Benzol	$2\text{–}3 \times 10^{-13}$	Benzine	3×10^{-15}
„ distilled...	6×10^{-14}	Hexane	4×10^{-16}

An experiment in which one of the plates was heated failed to show the presence of a thermo e.m.f. of so much as 1 volt, much less that required by Liebenow's formula when applied to insulators. G. E. A

2383. *Capacity of Aluminium Cells.* **A. Franchetti.** (Rivista Sci. Industriale, 33. pp. 121–123, Aug. 15, 1901. From the Rivista Tecnica di Torino.)—The author has measured the electrolytic capacity of cells composed of two aluminium electrodes in a 20 per cent. solution of the double tartrate of sodium and potassium. He determined the advance of the current over the pressure by the three-ammeter method, and also by plotting the curves by a Joubert contact-maker. At a constant frequency of 42 $\sim$, the capacity of the cell per sq. cm. of electrode was in microfarads at 87·5 volts 0·058; at 159 volts, 0·069; at 162·5 volts, 0·083; and at 171·5 volts, 0·127. At a pressure of about 200 volts, the current rose very rapidly and increased

as the electrode surface was diminished. The capacity is independent of the frequency, but the ohmic resistance decreases more rapidly than the frequency increases. The cell does not sensibly change the forms of the current and pressure curves. G. H. B.

2384. *Use of Geissler Tubes for Measuring Small Capacities.* **J. Borgmann.** (Phys. Zeitschr. 2. pp. 651–653, Aug. 10, 1901.)—A paper on the same lines as that referred to in Abstract No. 1029 (1899). The capacity of a Geissler tube measured in this way, for different pressures of gas, increases from 0·85 c.g.s. units at atmospheric pressure, up to 4·62 at 1 mm. pressure, and then gradually decreases to 3·92 at ·04 mm. Interesting experiments are described on the capacities of various combinations of tubes. R. S. W.

2385. *Electrostatic Capacity of the Human Body.* **G. de Metz.** (Comptes Rendus, 133. pp. 333–335, Aug. 5, 1901.)—The human body acts, as regards capacity, exactly as a metallic conductor of the same shape and size would do. Its capacity varies with the posture and with the position of other conductors in its neighbourhood. On an insulating table in the centre of a large room, as far as possible from all conductors, the average value is about 0·00011 microfarad. J. E.-M.

2386. *d'Arsonval Galvanometers.* **G. Kümmell.** (Zeitschr. Elektrochem. 7. pp. 745–750, July 4, 1901.)—Experiments made at the Reichsanstalt show that a d'Arsonval galvanometer works under its best conditions when its period is double the period on open circuit. The total resistance of the galvanometer circuit is then very nearly that which makes the galvanometer dead-beat.

The author has determined for a number of d'Arsonval galvanometers the value of the resistance fulfilling this condition, and compares it with the value calculated from des Coudres' formula. The experimental value of the resistance is considerably higher than the calculated, being on the average about 75 per cent. more.

The author further studied the effect of variations in the field strength, by replacing the permanent magnet of a Siemens galvanometer by an electromagnet. The deflection for a given potential difference was found to be a maximum for a field strength of 144, the outside resistance being always adjusted to make the galvanometer dead-beat. Up to a field of 1,100 the ratio of resistance to the square of the field strength was constant.

G. H. B.

2387. *Galvanometer Shunt-box.* **W. Volkmann.** (Elektrotechn. Zeitschr. 22. p. 653, Aug. 15, 1901.)—The author connects to one galvanometer terminal, one terminal of each of, say, three shunts, 1/9, 1/99, and 1/9999; the other galvanometer terminal is connected to the other terminal of the 1/9 shunt; between this and the other terminal of the 1/99 shunt is a resistance equal to 9/10 of the galvanometer resistance; between the terminals of the 1/99 and 1/9999 shunts is a resistance equal to 99/1000, and between the terminal of the 1/9999 shunt and that of the shunt box is a resistance equal to 9999/10000 of the galvanometer resistance. These shunts and resistances are joined up to contact blocks having six plug-holes and three plugs, the different combinations of which give sensibilities equal to 1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7} times the unshunted sensibility, while the total resistance of the galvanometer and shunt box remains always the same. G. H. B.

2388. *Power-Factor Indicators.* **W. H. Browne, Jr.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 475–500, June and July, 1901.)—In cases where the power-factor of a station load can be adjusted to unity by varying the excitation of synchronous motors or converters, it is necessary to have some means of ascertaining the exact point of balance. This point is often determined by the minimum reading of an ammeter in the line, or by comparing the volt-amperes and watts. Both these methods are unreliable, for a small error in reading means a large error in balance, when the power-factor approaches unity. This is illustrated by curves.

To give accurate results for large power-factors, measurements must not involve the cosine, so that either the phase-angle itself or the wattless volt-amperes must be measured.

The author then describes various forms of phasemeters. Phasemeters measuring the angle directly are : Tuma's, in which a moving system of two coils with their planes at right angles carries the shunt current in one coil, and a current in quadrature with it in the other coil ; this system is in the field of two coils carrying the main current ; the deflection of the moving system is the phase angle. Anglemeyer, Korda, Hess, Rossi, and Arnò make use of the principle that if two coils, carrying equal currents, are inclined at an angle equal to the supplement of the phase angle between the currents, the resultant rotating field will have a constant value. If the inclination of the coils be varied till this condition is obtained, the phase angle is indicated directly. Phasemeters measuring a function of the phase angle are : Puluy's, in which two electromagnets carrying the two magnets vibrate two mirrors in planes normal to one another ; a ray of light reflected from the two mirrors on to a screen describes an ellipse ; if one magnet only acts, the ray will describe a straight line ; the ratio of the length of this line, cut off by the ellipse, to its whole length, is the sine of the phase angle.

Moreland's and Claude's phasemeters are based on the same principle, but the latter measures the cosine of half the phase angle. A Siemens dynamometer, having two fixed coils and one moving coil closed on itself, measures the cosine of the angle, which is deduced from three readings, one with one current through one coil, a second with the other current through the other coil, and a third with both currents. Arno's phasemeter is an ordinary dynamometer with an additional moving system consisting of a pair of short-circuited coils in planes at right angles to each other; it measures the tangent of the angle.

In Breitfield's method for three-phase currents, the main coil of an ordinary wattmeter is connected in one line, and the shunt coil, first between this and the second line, and next between the first and third lines ; from the two readings the tangent of the angle is deduced.

The General Electric Company's instrument is based on the principle that the ratio of the readings of two wattmeters used to measure the power of a three-phase system varies with the power-factor, and is unity when the power-factor is unity. The instrument consists of two wattmeters, the moving coils of which are attached to the same spindle.

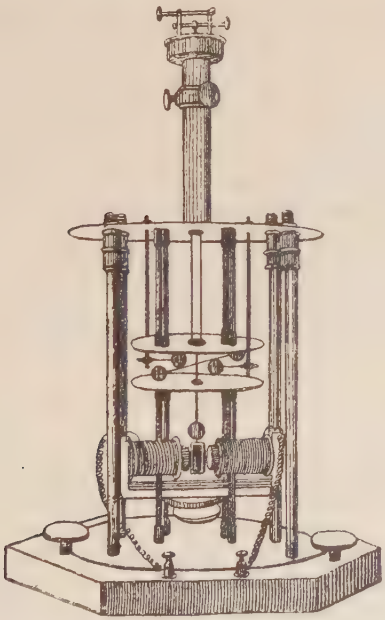
Phasemeters measuring the wattless volt-amperes or E.C. sin ϕ, are Dobrowolski's, in which fields due to the two currents act on a disc, as in an induction meter, with the difference that the shunt current is in phase with the e.m.f. There is torque on the disc only with a difference of phase and the torque is proportional to E.C. sin ϕ. The Allgemeine Elektrizität Gesellschaft's instrument is based on the same principle.

The author then gives curves and tables showing the results of experi

ments on a Siemens dynamometer, a Weston wattmeter, and a Shallenberger meter, and on power-factor meters. The dynamometer was used with a condenser in series with its pressure coil ; the Weston wattmeter was used on a two-phase system, and the Shallenberger meter was used with a non-inductive resistance in series with a condenser, in place of its choking coil. G. H. B.

2389. *Dielectric-Polarisation Balance.* **F. Maccarrone.** (N. Cimento, 2. pp. 88–96, Aug., 1901.)—This apparatus, which is designed to demonstrate and measure the polarisation of dielectric media, and to show the existence of a retardation of the polarisation due solely to viscosity, is represented in the accompanying figure.

It consists of two brass discs, half-way between which two glass discs (microscope cover glasses), lying in a vertical plane passing through the axis



of suspension, are bifilarly suspended. In one of the positions that these glass discs can be made to occupy by rotating the graduated head of the apparatus, two other glass discs are fixed from the top of the apparatus. The movement of the balance is observed by means of a reflecting mirror, and is made aperiodic by a magnetic damping arrangement. In working the apparatus to demonstrate dielectric phenomena, the upper brass disc is connected with a battery of Leyden jars, and the lower brass disc with earth. A gradually increasing repulsion of the movable from the fixed glass discs is seen. Both brass discs are now connected to earth ; the movable glass discs return *exactly* but only slowly (after several minutes sometimes) to their original positions. The method of measuring the absolute values of dielectric viscosity by means of the apparatus is sketched in the paper.

D. H. J.

2390. *Wehnelt Interrupter.* **H. Starke.** (Deutsch. Phys. Gesell., Verh. 3. 10. pp. 125–128, 1901.)—The author investigates the case of very small electrodes. The rate of interruption, other things being equal, can be increased by diminishing the diameter of the electrode wire. If the diameter is reduced to about 0·03 mm., and the current is regulated to about 0·02 amperes, the interruption is sharp and rapid enough to produce a tone in a telephone in the circuit. This method of interrupting the current is said to be particularly well suited for bridge and telephone methods of measuring electrolytic and other resistances. R. A.

2391. *Braun's Tubes for Measuring Electric Fields.* **W. I. Milham.** (Phys. Zeitschr. 2. pp. 637–639, Aug. 3, 1901.)—When the potential difference between the plates is altered by a given amount, the displacement of the light-spot from its normal position undergoes a proportional alteration. When the potential difference remains unchanged and the light-spot is not in its normal position, the light-spot tends to move steadily towards this position, with a speed proportional to the displacement. Practical directions are given. A. D.

2392. *New Physical Apparatus.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 478–479, May 11, 1901.)—A description, with prices, of three new sets of apparatus made by Ernecke of Berlin. The first is to illustrate Elihu Thomson's electrodynamic repulsion of a ring, rotation of a copper plate, lighting of a glow lamp by self-induction effect, &c. The application of 220 volts to the coil throws an aluminium ring to a height of 6–7 metres. The second apparatus is a cheap set for Hertz wave demonstration, the oscillators being much simplified and disturbing waves suppressed. The third is a practical form of Miethe's apparatus for producing spark spectra without air lines [see Abstract No. 1638 (1901)]. An illustration is given. G. E. A.

ALTERNATING CURRENTS AND MAGNETISM.

2393. *Theorem in Rotary Fields.* **A. Campbell.** (Elect. Rev. 49. p. 256, Aug. 16, 1901.)—The article explains and illustrates a theorem proved mathematically by the author in the appendix to his paper on Alternate-current Measurement [Abstract No. 1944 (1901)]. The theorem is: If two alternating fields of equal effective values, and any wave-forms, be inclined in space to one another at an angle equal to the supplement of the angle whose cosine is the power-factor between the two fields, then the resultant rotary field will have a constant effective value in all directions perpendicular to an axis of rotation. G. H. B.

2394. *Constancy of Magnets in Iron Cases.* **I. Klemenčič.** (Ann. d. Physik, 6. 1. pp. 174–180, Aug., 1901.)—The author observed the moments of three permanent magnets over a period of about five months, the magnets being kept in iron cases. These were formed of gas-pipe, the ends consisting of screwed iron plugs, and were lined with cottonwool to protect the magnets from vibration and shocks. During the first few days the magnets showed a small change, but after this the moment of each magnet remained constant within the limits of error of the experiments. The initial change was a decrease of moment of about $\frac{1}{4}$ per cent. in the case of one magnet and increases of 1 per cent. and $\frac{1}{3}$ per cent. in the other two magnets. These changes the author attributes to magnetisation or demagnetisation of the

iron case. To test the protective effect of the cases against shocks, a magnet, 10 cm. long in its case, was dropped ten times from a height of 1 metre on a stone floor : no change of moment resulted. The author further made measurements to determine the shielding of the cases against magnetic fields ; he concludes that an external field is diminished to less than one-third of its value inside the case. The experiments show that there is a great advantage in keeping magnets in iron cases. G. H. B.

2395. *Magnetisation by Intermittent Currents.* **K. Honda** and **S. Shimizu.** (Phys. Rev. 13. pp. 81–90, Aug., 1901.)—An intermittent direct current is produced by means of a Pupin interrupter [see Abstract No. 2043 (1900)]. This current, whose mean strength is measured by a Thomson graded galvanometer, is sent through a magnetising coil containing the wire under test. A magnetometer and compensating coil are placed due east of the magnetising coil. A summary of the results obtained is as follows : (1) For iron, steel, and nickel wires, the magnetisation in weak fields decreases as the frequency of the intermittent current increases ; while in stronger fields the magnetisation increases with the frequency. (2) The difference between the intensity of magnetisation with a definite frequency and that with a steady current increases as the field increases, and attains its maximum value in a field near that which gives the maximum permeability ; it then gradually decreases until it becomes zero (*i.e.*, when the intensity of magnetisation is the same with this frequency as with a steady current) ; as the field is further strengthened, the intensity of magnetisation becomes greater than that with a steady current. (3) In the hysteresis curve the field in which the change of magnetisation vanishes increases with the frequency. (4) The area of the hysteresis curve for the maximum field of 27·7 c.g.s. units increases with the frequency ; it reaches a maximum and then gradually decreases. These facts are accounted for on Wien's hypothesis that magnetisation has inertia. The paper is illustrated with I–H and μ–H curves of different frequencies for soft iron, tungsten steel, and nickel. E. C. R.

2396. *Pyro- and Piezo-magnetism of Crystals.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 1–19, 1901.)—The author gives an account of his observations on various crystals belonging to different crystallographic systems. He considers that the recorded observations determine, for the pyro- and piezo-magnetic excitement, only superior limiting values. The extraordinary smallness of the respective effects can be understood from the theory of ions, if it is remembered that in the expression for the magnetic action of a moved electron the velocity of light enters as denominator; yet, along with the conditions giving rise to the pyro- and piezo-magnetic effects, other unknown circumstances come in, so that the order of magnitude cannot be assigned beforehand with any certainty. The author's observations on this magnitude are therefore of interest. J. J. S.

2397. *Oscillations of Glow-Lamp Filaments in a Magnetic Field.* **R. Kempf-Hartmann.** (Phys. Zeitschr. 2. pp. 677–681, Aug. 24, 1901.)—It has often been observed that the carbon filaments of glow lamps in their cold condition are set in lively vibration by the slightest shock. The filament is at ordinary temperatures glass hard, and a stretched piece gives on plucking a somewhat high note. The whole filament forms an elastic system of very small inertia. With the naked eye its time of vibration cannot be observed.

On putting the lamp close to the ear a metallic sound can be heard, which seems to be made up of musical notes which have nothing in common with the large vibrations of the whole elastic system, for in these the number of oscillations is only about 20 per second. When the filament is incandescent it can be set in strong vibration with amplitudes of about 2·5 cm. These oscillations are very quickly damped, and the filament appears when glowing to have lost its elasticity. Stroboscopic measurement shows that a magnetic damping comes into play.

Let a permanent magnet (or an electromagnet with a steady current), be brought into the neighbourhood of a lamp, supplied with alternating current; or again, let an electromagnet excited by an alternating current be brought near a lamp with steady current. Then the band of light formed by moving the bright filament spreads out when the magnet is brought near. The form of the band and the amplitude of the vibrations, as well as their uniformity, depend on the situation of the magnet.

The explanation is simple. The current produces, according to its direction, a field of force, which either aids or opposes the permanent field. The glowing filament follows the attractions and repulsions. A magnetic needle would in the main behave in just the same way, but its inertia is so great in proportion to the moving forces that its motion only amounts to a slight tremor. Similar effects may be observed with various descriptions of electrodynamical measuring apparatus.

Two such systems consisting of a glow lamp and a permanent magnet may be arranged so that the vibrations of the filaments take place in directions at right angles, and thus Lissajons' figures may be obtained. Many experiments may be made with a single lamp and permanent magnet which will clearly illustrate the vibrations of elastic bodies.

The behaviour of the vibrating filaments is illustrated by photographs.

J. J. S.

2398. *Hall Effect in Very Thin Metallic Films.* **G. Moreau.** (Journ. de Physique, 10. pp. 478–498, Aug., 1901.)—The conclusion drawn from a series of experiments on films of silver and nickel is, that for films approaching 5×10^{-6} cm. thickness the accepted law does not apply. The results are most simply explained on the supposition that the outer layers of a film, to a depth of $2{\cdot}5 \times 10^{-6}$ cm., have properties differing from those of the interior. Thus the total thickness of a film is the sum of the outer layers together with the thickness of the homogeneous interior. Hence for films whose thickness is not much greater than 5×10 cm. the usual formula requires amendment so that it may express the fact that the qualities of the outer layers are different from those of the interior.

The accepted formula—

$$E = \frac{aHI}{e},$$

where E is the lateral e.m.f.; H the magnetic field; I the primary current; e the thickness of the film; a a coefficient characteristic of the metal—is not correct, since experiment proves that a varies with the thickness. This formula may, however, be transformed into the following:—

$$E = \frac{a}{\rho} LHW,$$

where L is the size of the film parallel to the equipotential surfaces of the

primary current, of which the potential difference per cm. is W, and ρ is the resistivity of the film.

But from experiment it is found that—

$$\rho = \frac{e}{A(e - 2{\cdot}5 \times 10^{-6})},$$

$$a = \frac{e}{B(e - 2{\cdot}5 \times 10^{-6})},$$

where A and B are true constants independent of the thickness ; hence—

$$a/\rho = A/B = K.$$

K is independent of the thickness until the critical thickness is reached. This then is the true coefficient of the Hall Effect, and the equation becomes—

$$E = KLHW.$$

The formula is an important one, showing as it does that the Hall Effect for the equipotential surfaces may exist without current. J. E.-M.

MEDICAL ELECTRICITY.

2399. *Recent Progress in Röntgen Rays.* **Rosenthal.** (Schweiz. Blätter Elektrotechn., Bern, 6. pp. 116–119, Aug. 8, 1901. From a paper read before the Munich Elekt. Verein.)—The author discusses tubes with massive anti-kathodes and means for regulating the vacuum ; an appliance, the punctograph, by von Angerer and himself, for locating bullets, &c., consisting of a pair of rings connected by a spring, the method of use being that the image of the bullet, in the body and between the two rings, is centred in the images of both rings, and the skin marked by a pencil at the centre of each ring ; and an appliance, the orthodiagraph, by Moritz, Munich, for tracing the true outline of the heart, &c., by making the vacuum-tube travel in correspondence with a travelling pencil on the other side of the patient's body, the effect of this arrangement being equivalent to that of optical parallel projection.

A. D.

REFERENCES.

2400. *Modifications of Discharges Caused by Dielectrics.* **K. v. Wesendonck.** (Phys. Rev. 12. pp. 375–376, June, 1901.)—An abstract of a paper which appeared in Wied. Ann. for 1893. R. S. W.

2401. *Damping of a Leyden-jar Discharge.* **Miss H. Brooks.** (Phil. Mag. 2. pp. 92–108, July, 1901.)—By means of a Rutherford detector, the damping of the oscillations and its dependence on the nature of the leads, length of spark-gap, pressure of air, hydrogen and carbonic acid gas in which the spark passes, and on the capacity of the jar itself are here investigated. E. H. B.

2402. *Regulation and Adjustment of Arc Lamps.* **M. E. Chester.** (Elect. Rev. 49. pp. 340–341, Aug. 30, 1901. From the "Technograph.")—The author gives a number of practical notes on the working of various types of arc lamps, with suggestions for remedying defects and avoiding errors in adjustment of the mechanism. A. H. A.

2403. *Measuring the Dispersion of Charges in Air.* **L. Kann.** (Phys. Zeitschr. 2. pp. 621–623, July 27, 1901.)—This paper describes a self-registering apparatus for this purpose. A. D.

2404. *Coherers.* **A. F. Collins.** (Elect. World and Engineer, 38. pp. 251–253, Aug. 17, 1901.)—This is an article giving briefly the history and more essential details of construction of coherers. P. E. S.

2405. *Selenium Cell for Demonstration.* **J. W. Giltay.** (Phys. Zeitschr. 2. pp. 675–677, Aug. 24, 1901.)—This paper describes an apparatus designed to demonstrate the effect of light upon selenium. J. J. S

2406. *Application of the Principle of Energy to Electrodynamic and Electromagnetic Phenomena.* **E. Sarrau.** (Comptes Rendus, 133. pp. 402–407, Aug. 26, 1901.)

2407. *Three-Phase Theory.* **A. Russell.** (Electrician, 47. pp. 639–643, Aug. 16, 1901.)—The author gives solutions of several three-phase problems, without any assumption as to wave form. Amongst the problems considered are (1) the magnitudes and phase differences of the p.d.'s between the mains in three-phase systems. (2) The graphical representation of the voltages in the three-arms of the load (star winding). (3) The potentials to earth of the mains. (4) Diagrams of the currents in a mesh winding. (5) The measurement of power in three-phase circuits. W. G. R.

2408. *Application of Lagrange's Equations to Electrodynamic and Electromagnetic Phenomena.* **E. Sarrau.** (Comptes Rendus, 133. pp. 421–425, Sept. 2, 1901.)

2409. *Induction in an Open Circuit.* **J. Koenigsberger.** (Phys. Zeitschr. 2. pp. 475–476, 1901.)—A study of the induced e.m.f. in an open circuit by means of the quadrant electrometer. E. E. F.

2410. *Secular Motion of Earth's Mean Magnetic Axis.* **L. A. Bauer.** (Terrestrial Magnetism, 6. pp. 73–75, July, 1901.)—A comparison of van Bemmelen's results with those obtained by the author and others. J. E.-M.

2411. *Unifilar Magnetometer of the Magnetic Survey of India.* **H. A. D. Fraser.** (Terrestrial Magnetism, 6. pp. 65–69, July, 1901.)—A concise description of the standard form of instrument used in the survey. J. E.-M.

2412. *Earth's Horizontal Magnetic Force.* **W. Watson.** (Terrestrial Magnetism, 6. pp. 70–72, July, 1901.)—A graphic method for determining the corrections to be applied in evaluating H. J. E.-M.

2413. *Electric Discharges and Allied Phenomena.* **K. R. Johnson.** (Phys. Zeitschr. 2. pp. 648–651, Aug. 10, 1901.)—In this paper the following phenomena are discussed and compared: (1) The behaviour of the spark potential in the case of electric discharges. (2) The electric oscillations in straight wires connected to the conductors of an influence machine. (3) The production of inflammable gas by high-pressure discharges between Wollaston pointed electrodes. (4) The phenomena of the Wehnelt interrupter. J. J. S.

2414. *Report of Magnetic Observations at Falmouth Observatory for the Year* 1900. Latitude 50° 9′ 0″ N., Longitude 5° 4′ 35″ W.; height, 167 feet above mean sea-level. **E. Kitto.** (Roy. Soc., Proc. 68. pp. 415–420, Sept. 12, 1901.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2415. *Argon and its Companions.* **W. Ramsay** and **M. W. Travers.** Roy. Soc., Proc. 67. pp. 329–333, Jan. 8, 1901 ; Roy. Soc., Phil. Trans. 197. pp. 47–89, July 29, 1901.)—The latter is a monograph (of which the former is an abstract) of the author's work on these gases, giving in detail the preparations of neon, krypton, and xenon, the physical properties of the group, and the methods of determination, with nine illustrations, tables, curves, and a plate of the spectra of Ne, Kr, and X. "Metargon" [see Abstract No. 1370 (1898)] is definitively abandoned : its supposed spectrum was due to carbon in the phosphorus used for removing oxygen. It is shown that if these gases be monatomic, with atomic weights of He, 4 ; Ne, 20 ; A, 40 ; Kr, 82 ; X, 128 ; or double their densities, they fall naturally into position in the periodic table ; it has not, however, been found possible to deduce accurately the properties of any one of them from those of its congeners. Measurements of the spectra by E. C. C. Baly will shortly be published. The spectra of Ne, Kr, and X cannot be detected in crude argon, even photographically. The colours are—helium, yellow ; argon, red-purple ; neon, brilliant orange-pink "flame colour" ; krypton, pale violet ; xenon, sky-blue. The monograph is also published entire in Zeitschr. Phys. Chem., 38. Nov. 1, 1901, pp. 641–689.

S. R.

2416. *Hydrogen Peroxide as an Acid.* **Bredig.** (Zeitschr. Elektrochem. 7. pp. 622–624, May 16, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Freiburg.)—The author describes the following experiments made under his direction by Calvert, which give confirmation to the view that hydrogen peroxide is an acid. (1) The coefficient of distribution of hydrogen peroxide between ether or amyl alcohol and water is enormously diminished as soon as alkali is added. (2) The freezing-point of N/4 sodium hydroxide solution is not lowered by the addition of $\frac{1}{8}$ H_2O_2, although the latter lowers the freezing-point of water by 0·33°. (3) The velocity of hydrolysis of ethyl acetate by alkali is considerably diminished by the addition of hydrogen peroxide. (4) When sodium hydroxide solution is neutralised by an acid, its molecular conductivity diminishes to one-half to one-third of its original value, and the same is found to take place on the addition of hydrogen peroxide. The latter is a very weak acid and has about the same strength as hypochlorous acid, so that its salts show appreciable hydrolysis. The mobility of the anion of hydrogen peroxide in its salts is $a' = 45$. (5) It is shown by direct experiment that hydrogen peroxide in alkaline solution forms an anion which, on electrolysis, travels in the direction of the negative current.

T. H. P.

2417. *Tests of Aluminium Bronzes.* **L. Tetmayer.** (Revue de l'Él., Berne, 10. pp. 124–125, Aug. 31, 1901.)—Details are given of tests carried out in the laboratories of the Zurich Polytechnic School, at the request of the Neuhausen Aluminium Company, who provided the samples. The specific gravity first rises, and then falls, as the percentage of aluminium increases. The maximum strength for soft alloys was obtained with 3·4 per cent. Al, and for hard alloys with 1·4 per cent. Al.

For brass, the elasticity decreases with the increase of aluminium, and is extremely low with only 2 per cent. of the latter. Silicon increases the specific gravity, and reduces the elasticity.

Iron, in the proportion in which it was present in the alloys, was not observed to sensibly influence the physical characteristics.

Aluminium bronze, containing 10 per cent.Al with 1·5 per cent.Si and Fe, is too brittle to be of any practical value. As regards the abrasion by friction, the hard alloys, with less than 89·6 per cent.Cu, lose little in weight, while the soft alloys, with less than 6 per cent.Al, heat, and wear away rapidly.

J. B. C. K.

2418. *Dielectric Constants of Derivatives of Pyridine and Piperidine.* **R. Ladenburg.** (Zeitschr. Elektrochem. 7. pp. 815–817, Aug. 8, 1901.)—The dielectric constants of the following substances were determined at 22° C. by Drude's method, and were found to be as follows :—

Substance.	Formula.	E_{22}.
Pyridine	C_5H_5N	12·56
α-Picoline	C_5H_4MeN	9·46
β-Picoline	C_5H_4MeN	10·71
α-Ethylpyridine	C_5H_4EtN	8·56
α-Conyrine	C_5H_4PrN	7·86
α-Isopropylpyridine	$C_5H_4(CHMe_2)N$	7·68
αβ′-Methylethyl-pyridine	C_5H_3MeEtN	7·95
αα′-Lutidine	$C_5H_3Me_2N$	7·23
*S-Trimethylpyridine	$C_5H_2Me_3N$	6·64
Piperidine	$C_5H_{11}N$	4·33
α-Pipecoline	$C_5H_{10}MeN$	3·55
α-Coniine	$C_5H_{10}PrN$	3·03
α-Isopropylpiperidine	$C_5H_{10}(CHMe_2)N$	2·95
*S-Trimethylpiperidine	$C_5H_8Me_3N$	3·06
N-Methylpiperidine	$C_5H_{10}NMe$	2·90
N-Ethylpiperidine	$C_5H_{10}NEt$	2·49
N-Isopropylpiperidine	$C_5H_{10}N(CHMe_2)$	2·26
*N-Methyl-α-pipecoline	C_5H_9MeNMe	2·17

The maximum error in the determinations was not greater than 2 per cent., but the substances marked with an asterisk were available only in small quantities, and their degree of purity could not be determined.

In all cases the displacement of a hydrogen atom leads to a lowering of the dielectric constant, and this effect is most marked when the replacing group is of high molecular weight, and occupies a position near to the nitrogen atom.

T. M. L.

2419. *Molecular Weight at the Boiling-point.* **de Forcrand.** (Comptes Rendus, 133. pp. 368–371, Aug. 12, 1901.)—The author has shown in a previous paper [see Abstract No. 1497 (1901)], that for all chemical or physical phenomena, the ratio $(L + S)/T$ has a constant value of 30, where L is the heat of liquefaction of a gas molecule, S the heat of solidification of this liquid molecule, and T the absolute boiling-point of the compound. The numbers experimentally obtained for the heats of liquefaction and solidification refer, however, not to molecules but to 1 gm. of the substance; denoting these values by l and s, the above relation becomes : $(L + S)M/T = 30$, M being the molecular weight. A means is thus furnished of determining the molecular

weight of a compound at its boiling-point ; the numbers obtained in this way will differ from the true values by not more than 1/15, or 6·7 per cent., which is the greatest error observed in the relation given above. For bromine, the molecular weight thus given is 166, corresponding with $2{\cdot}07Br$: for acetic acid, 97·02 or $1{\cdot}61\ C_2H_4O_2$, which agrees well with the indication of the vapour density ; for iodine, 381·04 or 3I, in accord with the latest researches, which give numbers varying from 2 to 4I, according to the concentration ; for mercury M = 237, corresponding with $1{\cdot}18Hg$; sulphur gives 266·1, pointing to a molecule $8{\cdot}31S$; for nitric acid M = 86·44, the mean molecule being $1{\cdot}37HNO_3$; whilst for nitric anhydride, the molecular weight has a value 79·75, which corresponds with $0{\cdot}74N_2O_5$, and indicates that the solidification of liquid nitric anhydride is accompanied by polymerisation, during which heat is evolved. T. H. P.

2420. *Molecular Weight of Chloral Hydrate at the Boiling-point.* **de Forcrand.** (Comptes Rendus, 133. pp. 474–476, Sept. 16, 1901.)—The author applies the relation [previously given by him, see preceding Abstract], existing between the latent heats of fusion and volatilisation, absolute boiling-point and molecular weight, to determine the molecular weight of chloral hydrate. The result seems to indicate that this compound is not completely dissociated at its boiling-point. T. H. P.

2421. *Heats of Volatilisation and of Fusion of some Elements.* **de Forcrand.** (Comptes Rendus, 133. pp. 513–515, Sept. 30, 1901.) [See also preceding Abstract.]—From the general equation $(L + S)/T = (l + s)M/T = 30$, the value of $(L + S)$ can be calculated when T and M are known. This gives a means of determining the latent heat of volatilisation of an element when no direct measurement has been made. For example, in the case of phosphorus, which has the molecular weight 124 in freezing benzene or in boiling carbon bisulphide or in the state of vapour, T = 560° absolute and S = 5 cals., so that the latent heat of volatilisation l is 130·4 cals. The sum of the heats of fusion and of volatilisation for an atomic proportion of phosphorus is therefore 4,200, and knowing that P (solid white) + H_3 = PH_3 + 4,900 cals., we have P (gas) + H_3 = PH_3 + 9,100 cals., a heat of formation rather less than that of ammonia from its elements (12,200). Similarly in the case of arsenic, $(l + s) = 68{\cdot}5$ cals., from which it follows that As (gas) + H_3 = AsH_3 − 39,060 cals. ; but it must be noted that the molecular weight of arsenic (300) is only known at the boiling-point, and in heating arsenic up to this temperature molecular charges may occur, resulting in manifestations of heat. Making the same reservation for selenium, we have Se (gas) + H_2 = SeH_2 − 4,805 cals. Also in the case of carbon, taking the boiling-point as 3,000° and the molecular weight as 24, the value 90,000 cals. is obtained for $(L + S)$, allotropic changes being neglected. T. H. P.

2422. *Chemical Reactions in the System—Ether—Water—Hydrochloric Acid.* **F. Jüttner.** (Zeitschr. Phys. Chem. 38. pp. 56–75, Aug. 6, 1901.)—An explanation is sought of the following facts (established by Schuncke) :—

(*a*) Ether and water, when saturated with respect to HCl gas at 0° C. and atmospheric pressure, contain respectively 35·6 per cent. and 45·2 per cent. hydrochloric acid.

(*b*) If these two solutions be mixed there is a great evolution of HCl gas and production of heat, and a homogeneous mixture results (one liquid phase).

(*c*) If ether be shaken with a 31·61 per cent. aqueous HCl solution it will

only take up 0·236 per cent. HCl. Extrapolation to very concentrated aqueous HCl solution gives for the partition coefficient of HCl between ether and water the value $1/10^{-3}$. On the other hand, the ratio of the solubilities gives 1/1·3.

The explanation suggested is that ether and HCl combine to form a hydrochloride analogous to the compound obtained by Friedel in the case of methyl ether, or to the compounds between alkyl substituted pyrones and HCl investigated by Collie and Tickle, and Collie and Steele.

It is assumed that the partition coefficient of this ether hydrochloride between ether and water lies very much towards the water. With these assumptions the above facts can be fairly well explained. An attempt is made to apply the law of mass-action to the equilibrium in the aqueous solution between the ether, hydrochloric acid, and ether hydrochloride, but reference must be made to the original paper for an account of this.

F. G. D.

2423. *Solid Solutions in Mixtures of Three Substances.* **G. Bruni.** (Accad. Lincei, Atti, 9. pp. 232–241, 1900.)—This paper consists of a study of physical equilibrium in ternary systems in which solid solutions may form. Diagrams are given corresponding to the different possible types of substances forming the system.—A paper on similar lines by **G. Bruni** and **F. Gorni** appears in the Accad. Lincei, Atti, 9. pp. 326–332, Dec. 2, 1900. A. D.

2424. *Carbon at High Pressures and Temperatures.* **Q. Majorana.** (Accad. Lincei, Atti, 9. pp. 224–232, 1900.)—This paper contains a description of experiments on exposing carbon to high temperatures and heavy pressures, with the result of producing compact graphite. For crystallisation of carbon, it is probable that the use of a solvent is necessary. A. D.

2425. *Relation between Solubility and Heat of Solution.* **A. Campetti.** (Accad. Lincei, Atti, 10. pp. 99–102, Aug. 18, 1901.)—To express the heat given out on solution van't Hoff deduced the equation—

$$q = -\frac{4{\cdot}58\,(\log c_2 - \log c_1)\,T_1T_2}{T_2 - T_1}$$

where c_1 and c_2 are the concentrations of saturated solutions of substances at temperatures T_1 and T_2, not greatly differing from one another. The equation, which is true only for non-dissociating substances of small solubility, was verified by van't Hoff for succinic, benzoic, salicylic, and boric acids. The present paper gives an account of experimental determinations of both the solubility and heat of solution of *strong* solutions of urea and of mannite, and it is found that the experimental values for the heat of solution agree with those calculated from the above formula, if c_1 and c_2 are taken to represent the number of grammes of substance dissolved in the same weight of solvent, and not, as in van't Hoff's equation, the number of grammes of dissolved substance in 100 c.c. of the solution. D. H. J.

2426. *Temperature-coefficient of Susceptibility of Salt-solutions of the Iron Group, especially of Ferric Chloride.* **H. Mosler.** (Ann. d. Physik, 6. 1. pp. 84–95, Aug., 1901.)—Jäger and Meyer have stated that the temperature coefficient of susceptibility of salt solutions of the iron group varies, independently of the concentration, from —0·00219 to —0·00305, that for an 18 per cent. solution of nickel nitrate alone rising to —0·00322. Plessner, on the other hand, working by Wiedemann's method, finds that the temperature coefficient is

in all cases —0·00356. In the investigation here described an improved form of Wiedemann's method was used, and the temperature coefficients were determined with a considerable degree of accuracy. In most cases the variations in the temperature coefficient due to changes of concentration are only slight and somewhat irregular; the mean values are, for ferric nitrate —0·00283, for cobalt nitrate —0·00273, for manganese sulphate 0·00266, and for nickel sulphate —0·00282. In the case of ferric chloride, however, a remarkable maximum occurs; solutions containing less than 28·5 per cent. or more than 38·5 per cent. of the salt have a normal temperature coefficient which is remarkably steady at —0·00270 (mean value), but between these limits the temperature coefficient rises to a maximum value, —0·00358, at 33 per cent. This maximum does not appear to be connected with any of the other chief physical properties of the solution, such as the relative permeability, the electrical conductivity or the freezing-point depression, and no explanation has been found of the exceptional behaviour of these solutions. T. M. L.

2427. *Electrolytic Conductivity of the Hydrates of Sodium and Potassium in Solution in Glycerine.* **G. di Ciommo.** (N. Cimento, 2. pp. 81–87, Aug., 1901.)—Monti (Atti del R. Istituto Keulto, 1891–2) studied the molecular conductivity of *dilute* solutions of some alkaline salts in mixtures of glycerine and water. The present work, in which the conductivity was determined for *strong* solutions of caustic soda and potash in glycerine of fixed strength (96 per cent. glycerine, 4 per cent. water) is an amplification of Monti's work. The conductivity was determined by the telephone method at temperatures of 14°, 18°, 24°, and 30° for sodium hydrate solutions from 0·38 per cent. to 13·4 per cent. and for potash solutions from 0·47 to 16 per cent. strength. From the results it appears that (1) in glycerine, as in aqueous solutions, we find maxima of conductivity. In the case of the glycerine solutions the ratio of the concentrations corresponding to the maxima is equal to the ratio of the molecular weights of potash and soda. (2) The conductivity in glycerine solution is much less than in aqueous solution; thus the maximum conductivities of potash and soda in glycerine solution are less than the millionth part of the conductivities in aqueous solution. (3) The temperature coefficient is much larger for glycerine than for aqueous solutions. D. H. J.

2428. *Calorimetric Properties of Ferromagnetic Bodies.* **B. Hill.** (Deutsch. Phys. Gesell., Verh. 3. 10. pp. 113–118, 1901.)—Certain alloys of iron and nickel, which become non-magnetic when heated, and can be cooled to ordinary temperatures without returning to the magnetic condition, allow of the comparison of the two allotropic modifications at the same temperature. The author makes this comparison, in the first place, for certain specimens of nickel steel as regards their specific heats. The specific heat in the non-magnetic state is always greater than in the magnetic state, the difference, as a rule, diminishing with increase of temperature. The properties of one specimen made possible the determination of its latent heat of conversion. So also in the case of iron, the greater the magnetic susceptibility of a specimen the less is its specific heat, in accordance with the theory that iron ordinarily consists of a mixture of two modifications—one magnetic, the other non-magnetic. W. E. T.

2429. *Chemical Equilibrium.* **O. Boudouard.** (Annal. Chim. Phys. 24. pp. 5–85, Sept., 1901.)—The author gives an account of extensive series of

experiments on the reaction $2CO = CO_2 + C$ and its inverse. The decomposition of CO in the presence of metallic oxides is a function of the time and temperature, the quantity of CO_2 formed increasing regularly up to a certain limit, and the rapidity of the reaction being a function of the surfaces of the oxide exposed. Similarly the decomposition of CO_2 in presence of carbon is a function of the time and temperature, the limit of the reaction being, for the same temperature, the same as in the inverse reaction. The numerical results obtained afford a verification of the formula due to Le Chatelier [see Abstract No. 661 (1901)], the value $-21{\cdot}4$ being found for the constant involved in it. The influences of temperature and pressure on the reactions are in accordance with the general law of "the opposition of action and reaction" enunciated by Le Chatelier (Ann. d. Mines, 8. 13. p. 157). Important practical applications of the results obtained are pointed out. In conclusion the author discusses the action of the metallic oxides and the carbon in the decompositions in question, and considers that they play a part analogous to that of porous bodies which are able to absorb gases with considerable evolution of heat. W. E. T.

2430. *Possible Significance of Changing Atomic Volume.* **T. W. Richards.** (Amer. Acad., Proc. 37. pp. 3–17, June, 1901.)—A theoretical paper which does not admit of brief abstraction. Tables are given of the increase or diminution of volume occurring when metals form oxides, chlorides, or hydroxides, in connection with physical changes, expressed in terms of internal stress. An atom is conceived as "a compressible field of force possessing two attractive attributes, chemical affinity and gravitation, both of which are concerned in chemical action." It is pointed out that changing atomic volume may be used as an approximate measure of the pressure which causes it, and therefore of the affinity which causes the pressure. Some of the difficulties in the way of exact interpretation are indicated, and hints as to possible modes of overcoming them. The chief outcome of the paper is the following postulate: "The atomic volume is not constant, but a function of pressure and temperature, and probably of electrical stress, while chemical affinity is possibly a function of mass." A modification of the atomic theory is tentatively proposed which contends that "we have no right to disregard the compressible environments around the centres of gravity and affinity." S. R.

2431. *Vapour Tension of Solutions.* **A. Ponsot.** (Comptes Rendus, 133. pp. 341–344, Aug. 5, 1901.)—Experimental results lead to the conclusion that, in general, if the substitution of a body A for a body B in the compound BC, dissolved in a liquid which does not take part in the reaction, produces heat, the vapour tension of the solvent is greater when it contains a given mass of AC than when it contains an equivalent mass of BC. Measurements of the lowering of freezing-points of solutions confirm the above conclusion and lead to the more general law that, when the substitution of one radical for another produces heat, the osmotic and other moduli of the first are smaller than those of the second. J. E.-M.

2432. *Iron and Steel from the Point of View of the Phase-Doctrine.* **H. J. v. Jonstorff.** (Electro-Chemist, 1. pp. 173–174, July, 1901. Paper read before the Iron and Steel Institute, May, 1901.)—A summary is given of the results obtained by various experimenters on the solubility of carbon in solid iron during cementation at different temperatures. Attention is specially called to some experiments made by Saniter, which show that at 900° C. the

action probably occurs in two stages, only martensite and cementite appearing during the first fourteen hours' heating, but graphite being subsequently formed. It is therefore suggested that at 1,000° C. the iron at first absorbs the carbon with the formation of martensite (mixed crystals of iron and carbon), and that when the iron is saturated with carbon the carbon is deposited in the form of cementite (Fe_3C) and not as graphite, the graphite only appearing locally on the surface of the metal where the whole of the iron has been turned into cementite by the absorption of 6·67 per cent. of carbon. Above 1,000° C., however, there can exist no doubt that graphite has a greater stability than cementite, and that at the higher temperatures the reverse change of cementite into graphite and martensite would take place. T. M. L.

2433. *Deposition of Copper from Various Electrolytes.* **A. A. Beadle.** (Electro-Chemist, 1. pp. 168–169, July, 1901.)—Electrolytes other than copper sulphate are here considered for the purpose of studying the structure of the deposit under varying conditions. Experiments were made with the following solutions :—

Solution.	Composition.	Grs. of Cu per litre of sol.	Sp. resist. in ohms per c.c.
A	Copper sulphate acidified with H_2SO_4	258	2·2
B	Copper nitrate acidified with HNO_3	352	2·2
C	Copper potassio-cyanide with excess of KCN.....	47	3·66
D	Cupric acetate acidified with acetic acid	5	45·0
F	Copper am.-sulphate acidified with H_2SO_4	41	1·22

Current densities varying from 10–320 amperes per square foot were employed, and the same current allowed to pass till decided signs of irregularity, such as sponginess, nodules, or spikes, appeared. Soluble anodes were employed.

The author finds that the safe rate of deposit is roughly proportionate to the amount of copper in solution. O. J. S.

2434. *Preparation of Osmotic Membranes by Electrolysis.* **H. N. Morse** and **D. W. Horn.** (Chem. News, 84. pp. 104–105, Aug. 30, 1901. From the Amer. Chem. Journ. 26. No. 1.)—The authors find that strong semi-permeable membranes of copper ferrocyanide may be formed in the walls of porous cells by means of electrolytic deposition. The air is first removed from the walls of the cell by placing the latter in a beaker, and filling both the cell and beaker nearly to the top of the former with a boiled solution of 0·5 grm. of potassium sulphate in a litre of water; on passing a current from the outside to the inside of the cell by means of electrodes dipping into the liquid, the level of the latter inside rises rapidly, and effectively sweeps out the air. After washing, the wet cup is placed in a beaker surrounded with an electrode of sheet copper completely encircling it, a platinum electrode being placed inside the cell. The electrodes are connected with the current generator, so that the current flows the moment the liquids are added; the latter consist of N/10

or N/5 copper sulphate solution for the outside, and N/10 or N/5 potassium ferrocyanide solution for the inside of the cell, and these are added as nearly simultaneously as possible. At first, considerable endosmose occurs in the direction of the current, that is, from the copper solution to the ferrocyanide, but no copper or ferrocyanide traverse the cell walls. The membrane soon begins to form, the resistance at the same time rising rapidly. Membranes thus formed are found to resist pressures of 4·5 atmospheres and possibly more. T. H. P.

2435. *Colour of the Ions.* **G. Vaillant.** (Comptes Rendus, 133. pp. 366–368, Aug. 12, 1901.)—By means of spectro-photometric measurements of solutions of the permanganates of potassium, barium, and zinc, the author experimentally confirms the following conclusions drawn by applying the ionic hypothesis to the colouration of solutions : (1) In solutions of salts which are completely ionised, and which contain only one coloured ion, the colour is independent of the nature of the other ion. (2) If the ionisation is incomplete, the colouration varies with the nature of the non-coloured ion. (3) In the general case, the equation connecting the colouration of an equation of a solution of any concentration with its degree of ionisation contains two constants, one characterising the unionised, and the other the ionised molecule. T. H. P.

2436. *Theory of the Aluminium Rectifier.* **W. Mitkiewicz.** (Phys. Zeitschr. 2. pp. 747–750, Sept. 28, 1901.)—The author has arrived at the conclusion that when an aluminium valve is in action, the surface of the aluminium electrode is divided from the liquid by an insulating layer of aluminium oxide, or by some other compound of aluminium, formed by electrolysis. The passage of the current is only made possible by the circumstance that there are many gaps in the insulating layer, which only allow the current to pass in one direction. This view is confirmed by the fact that a microscopic examination of the luminous electrode separates it into a large number of luminous points. The rectifier consists practically of an immense number of Wehnelt interrupters mounted in parallel. E. E. F.

2437. *Electrochemical Deposition.* **H. Boilbet.** (International Electrical Congress at Paris, Reports, pp. 303–305, 1901.)—In this paper the author refers to the extensive mechanical reproduction of medals and other works of art by pantographic methods, from a large-sized model reproduced in electrolytic copper from the original. Owing to the softness of electrolytic copper, it is necessary, in order to prevent damage to the model from the pantograph stylus, to electroplate it with nickel. The author suggests that experiments should be made as to whether chromium could with advantage be electrically deposited on the copper in the place of nickel. He then suggests that it would be interesting to know if any successful attempts have been made in the direction of electroplating silver and gold directly upon aluminium. G. W. de T.

2438. *Electric Copper Refining.* **G. E. Walsh.** (Elect. Rev. N.Y. 39. pp. 213–214, Aug. 24, 1901.)—After remarking upon the progress of the copper industry, and dealing with the outputs of various mines, the author proceeds to deal with the efficiency and economy of the different electrolytic processes now in vogue.

When the electrolytic process was first attempted, the cost of producing refined copper by this method was as high as $30 per ton, and even eight years ago the charge was $20. This has now come down to $8 and $10 per ton. From the mines to the refinery the copper is in crude bars or cakes, which are tested first as to quality and value, and then heated in a reverberatory furnace, and prepared for the electrolytic bath in the form of anodes. In each tank of the refinery there are about 20 to 25 anodes and 25 kathodes, a free circulation being kept up between the tanks. An overflow pipe keeps the tanks properly filled, new fluid entering as fast as the other is drawn off.

The electrolyte contains in solution 16 per cent. bluestone and 5 per cent. sulphuric acid; the average current required for a refinery is about 10 amperes per square foot, counting both sides of the anode plate. The impurities, containing gold and silver, are deposited at the bottom of the tanks in the form of a black mud, which is afterwards screened, and treated for the recovery of its contents.

The cost of maintaining a plant at the highest efficiency has been found to be greater in the series process than in the multiple, but the former saves some loss of energy. It is estimated by modern refiners that there is a saving of nearly $2 per ton of refined copper in the multiple system. In some mining regions, where the refinery is a part of a converting establishment, and run in conjunction with it, the saving has been as much as $3·50 per ton. The average current efficiency of the multiple process is 95 per cent., as against 90 per cent. for the series process, under similar conditions. Where the electric power is expensive, or fuel high-priced, the difference in the current efficiency of the two processes must always decide in favour of the multiple process.

J. L. F. V.

2439. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 28. pp. 229–236, Aug. 17, 1901.)—An illustrated account is given of W. Borchers' electric furnaces of the incandescent and arc types, in which the waste heat is utilised by means of water-jackets, and in which the waste gases are filtered through a layer of porous charcoal, so that, being free from dust, they can be utilised outside the furnace; the application is described of the same principle to furnaces in which calcium carbide, as it is produced, falls from between the electrodes, and, solidifying, forms a continuous solid cake which sinks into a bed of charcoal powder, where fragments are from time to time broken off at the lower end to make way for the fresh carbide which is constantly being added above. There are also described and figured: The resistance-furnace of Gin and Leleux; the arrangement of Roesler and Carlson in which it is sought to prevent excessive local heating by using several small electrodes in place of one large one; the arc-furnace of Contardo, in which the arc passes between horizontal electrodes placed on the hearth of a reverberatory furnace, to which the charge is fed through channels in the cover of the furnace, and is traversed by the escaping waste gases, and therefore heated both by these gases and by radiation from the furnace; the furnace of the Société Electrochimique Volta (of Geneva), which is so arranged that the portion of the charge vaporised by the arc has to pass through a portion of the charge still fluid, where it for the most part condenses, before it can escape into the air; the furnace of F. J. Machalske (see *Electrical World*, 37. p. 360, 1901) for the production of phosphorus from natural phosphates, in which it is claimed that a new silver-like metal has been produced; the rotatory furnace of F. E. Hatch (see *Electrical World*, 36. p. 543, 1900); and the glass-melting furnaces of Voeker and Luhne.

W. G. M.

REFERENCES.

2440. *Concentration Changes in Edison's Accumulator.* **E. F. Roeber.** (Elect. World and Engineer, 37. pp. 1105–1108, June 29, 1901.)—The author calculates the maximum concentration changes due to the difference in ionic velocities. W. R. C.

2441. *Phase-rule.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 401–403, June, 1901.)—Wind bases his demonstration of the phase-rule [see Abstract No. 677 (1900)] on a theorem which, as is here shown, may be regarded as one way of stating the conditions of equilibrium of a system given in a former memoir [see Abstract No. 937 (1901)]. R. E. B.

2442. *A New Thermo-chemical Notation.* **J. H. Pollok.** (Roy. Dublin Soc., Proc. 9. pp. 495–505, July 6, 1901.)—A system of notation is introduced which lends itself to calculation more readily than those of Thomsen and Berthelot. T. M. L.

2443. *Polarisation Capacity of Platinum.* **E. Warburg.** (Ann. d. Physik, 6. 1. pp. 125–135, Aug., 1901.)—A mathematical paper, in which thermodynamical considerations are brought to bear on the polarisation of platinum in dilute sulphuric acid. T. H. P.

2444. *Analysis of Gases by Electricity.* **Berthelot.** (Annal. Chim. Phys. 23. pp. 433–447, Aug., 1901.)—This paper, which is chiefly of chemical interest, is a systematic summary of the effects of electric sparking on gases and on the vapours of volatile liquids. N. L.

2445. *Crystallisation of Salt Solutions.* **H. M. Dawson.** (Nature, 64. pp. 336–338, Aug. 1, 1901.)—This paper gives a short account of the principles involved, and the methods employed, in the solution of the problems connected with the crystallisation of salt solutions, as exemplified in van't Hoff's researches on the formation of oceanic salt deposits. [See Abstracts Nos. 226, 1114, 1116, 1879 (1900) and 528, 665, 933, 1538 (1901).] N. L.

2446. *Moissan's Researches on Fluorine and the Fluorine Compounds.* **H. F. Keller.** (Frank. Inst., Journ. 152. pp. 123–140, Aug., 1901.)—This paper, which is chiefly of chemical interest, gives a useful summary of Moissan's work on fluorine; ten illustrations of apparatus are given. [See also Abstract No. 2072 (1900).] N. L.

2447. *Density of Copper-Tin, Copper-Zinc, and Tin-Zinc Alloys.* **E. Maey.** (Zeitschr. Phys. Chem. 38. pp. 289–291, Sept. 17, 1901.)—Alloys of varying composition were prepared and their densities determined; the results are given in tabular form, and are compared with those obtained by Riche and Mallet. N. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2448. *Speed Variation of Compound Engine.* **W. L. Abbott.** (Eng. Record, 44. pp. 155–158, Aug. 17, 1901. From the "Technograph.")—The object of the investigation is to determine the maximum angular displacement which can be produced between the armatures of two dynamos, driven by two separate steam engines at the same average speed, owing to the cyclical variation in the speed of the engines. Considering one engine, the author plots the combined crank-effort diagram from the indicator cards of the two cylinders, and, by a system of tabulation and correction, obtains successively diagrams of the deviation of velocity and of displacement, from the values they would have if the rotation were perfectly uniform; the maximum ordinate of the latter diagram is the value sought. [The deviation of crank-effort from the mean is of course a curve of accelerations on a displacement base, and from this the curves for the deviation of velocity and displacement might be found graphically.] Diagrams and a description of the calculations are given. H. R. C.

2449. *Furnace Temperatures.* **W. H. Booth.** (Elect. Rev. 49. pp. 338–340, Aug. 30, 1901.)—To illustrate the actions taking place in the combustion of solid fuel, and the need of refractory furnaces for that process, the following average of eighteen analyses of Newcastle coal is taken as a basis :—Fixed carbon 48·84 per cent.; volatile carbon 33·29 per cent.; hydrogen 5·31 per cent.; oxygen 5·69 per cent.; nitrogen 1·35 per cent.; sulphur 1·24 per cent.; ash 3·77 per cent. Calorific capacity of the coal 15,203 B.Th.U. The calorific capacity of amorphous carbon being about 14,647 B.Th.U., that of the fixed carbon in the above coal must be 7,150 B.Th.U., which represents the heat available for transforming solid coal into gaseous hydrocarbons. The 18 lbs. of air per lb. of coal, generally supplied for combustion, must also be heated by it to the temperature of combustion, and the ash and escaping gases also carry away some of the heat. The flame temperature of carbon with the minimum quantity of air (11·6 lbs.) being 4,892° F., that of 1 lb. of the coal with 18 lbs. of air will be $12{\cdot}6/19 \times 4{,}892 = 3{,}243°$ F. The 48·84 per cent. carbon will therefore produce $3{,}243 \times 0{\cdot}4884 = 1{,}584°$ F. This maximum will be reduced in proportion to the different specific heats of the gases in the products of combustion; these being: nitrogen 0·244; carbonic acid 0·217; steam 0·480; hydrogen 3·410; olefiant gas 0·418; marsh gas 0·593. These specific heats vary at high temperatures, generally increasing with increase of temperature. In addition, the latent heat of evaporation of carbon, hydrogen, and oxygen from the solid must be considered. Assuming 7,000 heat units as the latent heat per lb. for all the volatile constituents of the coal, then $0{\cdot}474 \times 7{,}000 = 3{,}318$ units will be absorbed in gasification. This being deducted from the 7,150 total heat units found above, leaves 3,832 available heat units. If the gases were collected unburned, the temperature produced by the fire would have to be below their ignition-point. If half the air supply were sent through the fixed carbon and the other half supplied to the

evolved gases at a later period, that temperature would be doubled. Hence the necessity for regulating the air supply. Brick-lined furnaces are necessary to conserve the radiant heat from the incandescent carbon. The following figures are given :—

HEAT GENERATED BY THE COMBUSTION OF 1 LB. OF CARBON IN DIFFERENT STATES.

State of Carbon.	Product of Combustion.	B.Th.U. per lb.
Diamond	Carbon monoxide	3,915
„	„ dioxide	14,146
Graphite	„ „	14,222
Amorphous	„ monoxide	4,415
„	„ dioxide	14,647
Gaseous	„ monoxide	10,732
„	„ dioxide	20,963
Carbon monoxide.....	„ „	10,231

Metamorphic Conversions.		Heat absorbed.
Carbon (diamond)	to gas.....	6,316
„ (graphite)	to „	6,241
„ (amorphous)	to „	5,817
„ (diamond)	to carbon amorphous.....	499
„ (diamond)	to „ graphite	74·7
„ (graphite)	to „ amorphous.....	424

About half the weight of bituminous coal burns on the grate, and produces half the total heat of combustion ; but the vaporisation of the solid fuel absorbs so much heat that only one-fourth is found as sensible heat. The remaining three-fourths are developed between the fuel surface and the extreme range of combustion. Anthracite burns entirely as solid carbon, and hence the high local temperature at the grate bars. The chilling effect of fresh charges of fuel is much less with anthracite than with bituminous coal. Furnace temperatures are always lower than ordinary calculations make them, and many boiler furnaces cause additional loss by interposing very active heat-absorbing surfaces too close to the surface of the fire, thus preventing the proper ignition of the combustible gases. F. J. R.

2450. *Furnace Temperatures.* **C. C. Garrard.** (Elect. Rev. 49. pp. 382–383, Sept. 6, 1901.)—The author takes exception to W. H. Booth's term the "evaporation of carbon" [see preceding Abstract], holding that whilst such an action may occur in the electric furnace it does not exist in ordinary fuel furnaces. What was probably meant by Booth was the latent heat of vaporisation of the volatile hydrocarbons already existing in the coal, and therefore the proper way of arriving at the loss of heat at the grate by vaporisation of these compounds is to fractionate the coal, and calculate the result from the analysis and known latent heats of the constituents. As to the "latent heat of the vaporisation of carbon" being equal to the difference in the heat of combustion of carbon burned to its monoxide and that of the monoxide burned to dioxide respectively, the methods of combination of the two oxygen atoms in the CO_2 molecule are not necessarily identical, nor can it be proved that they enter into combination with the vaporised

carbon with exactly the same liberation of energy. This writer remarks that Booth neglects the effect of dissociation on the maximum temperature obtainable in a furnace, and shows by calculation that Booth's maximum 4,892° F. should be 4,172° F. Although this affects all his calculations it rather accentuates Booth's point as to the low temperature of the furnace, but this writer considers that pre-heating the air supply by the waste heat is the rational way of overcoming the difficulties alluded to by Booth. F. J. R.

GAS AND OIL ENGINES.

2451. *Gas Plants for Engines.* **J. E. Dowson.** (Inst. Civil Engin., Proc. 144. pp. 269–285, June, 1901.)—The author deals first with various points connected with the practical working and testing of gas plants. Referring to some tests made by Meyer, in which the quality of gas was found to vary with the rate of production, he states that, with an anthracite fire, the maximum production can be reduced 50 per cent. in a small generator, and 50 per cent. in a large one, without appreciably affecting the quality of the gas. In small generators fuel should be fed in frequently in small quantities; in large generators longer intervals may be allowed. When non-bituminous fuels are used, the introduction of fresh fuel does not affect the quality of gas, if the depth of fire be sufficient. The author does not advocate automatic stokers. The gas should have a calorific value of at least 1,200 calories per cubic metre, and should contain not less than 15 per cent. of hydrogen, to insure prompt ignition.

Describing the various types of gas-plant the author divides them into three classes:—

(1) Producer with jet of superheated steam, forcing in air, *e.g.*, the Dowson plant.

(2) Producer without steam-jet, and with blower to force in air, *e.g.*, the Lencauchez and Mond plants.

(3) Producer without steam-jet or blower, the air being drawn in by a suction pump attached to the gas engine, *e.g.*, the Bénier plant.

In the Dowson plant about 90 per cent. of the steam is decomposed, and, under best conditions, ¾ lb. per lb. of anthracite consumed.

The percentage of hydrogen in the gas should be as large as possible, provided that not more than 6 per cent. of carbon dioxide be present. In an Appendix are given results of ten tests of Dowson gas plants. The average calorific power of the gas is 1,432 calories per cubic metre, and the average heat efficiency 78·9 per cent. The author distributes the loss of heat for 80 per cent. efficiency as follows:—

Loss in boiler	7	per cent.
Undecomposed steam	1	,,
Unburnt anthracite	2	,,
Loss in radiation and cooling of gas	10	,,
	20	,,

In the Lencauchez plant there is no boiler, and air, saturated with moisture, is forced into the generator by a blower, driven by hand at starting, and afterwards by the engine. No complete tests of the plant are available.

In the Mond plant [see Abstract No. 1567 (1901)] the calorific value of the gas is 1,385 calories per cubic metre, and the heat efficiency 79 per cent.

In the Bénier plant air is drawn into the generator by a suction-pump

attached to the engine, and, as the quantity drawn in varies with the gas consumption, no gas-holder is needed, but each engine must have its own generator. Water is vaporised in the fire-grate, and mixes with the air before entering the fuel column. A test by Witz showed a calorific value of 1,149 calories per cubic metre. G. H. B.

AUTOMOBILISM.[1]

2452. *Motor Cycles.* **A. L. Clough.** (Horseless Age, 8. pp. 395–396, Aug. 7, 1901.)—Tricycles, being three-track vehicles, cannot go fast with comfort over ordinary roads. For motors, bicycles are therefore preferable. The motor should not be rigidly geared to the cycle, but preferably belted, to prevent the more sudden stresses on wheels and tires due to the power stroke of the motor at low speeds. The motor shaft and secondary shaft must have oil-tight bearings, or oil will get on to the contact-breaker and on to the belt pulley. A practical form of spring-supported motor is needed, to obviate the large dead load which the motor puts on a rigid construction, originally developed solely for carrying a live load. The front fork is severely strained by a rigid motor. For the same reason the stresses on tires are more severe, owing to the dead load, than in a tandem bicycle. Means for adjusting the tension of the driving belt from the saddle are desirable, forming a crude free clutch and low gear. E. H. C.-H.

2453. *Kuhlstein-Vollmer Vehicle.* (Horseless Age, 8. pp. 402–403, Aug. 7; and 462–463, Aug. 28, 1901. From the *Motorwagen.*)—In this car an underframe of rectangular channel iron carries a horizontal petrol engine towards its back end, with the crank chamber nearly over the rear axle of the car, and the cylinders in front. The latter are parallel, and the bodies are formed in one casting, which is bolted to the crank chamber. The pistons are coupled to cranks at 180°. The cylinder dimensions are 4·8 in. bore by 5·6 in. stroke, and the engine is rated at 9–10 b.h.p. The suction valves are automatic, and the exhaust valves are mechanically operated; they are placed in independent pockets, opening into the combustion chambers. The power is transmitted from one end of the crank-shaft, first by a short belt to a counter-shaft, pivoted in such a manner that the tension of the belt can be varied at will by the driver. The pivots of this shaft are concentric with the first motion shaft of the change-speed gear, which is driven from it by spur gearing. The change-speed gear is of the spur-wheel type, with teeth engaging by side contact. The second motion shaft of the change gear carries the differential gear, and the road wheels are driven from it by chain gears at either end. Three speeds forward, and one reverse, are obtained by the change gear, and the belt serves the purpose of a friction-clutch. A plan and elevation of the car mechanism, and details of the engine are given. C. R. D'E.

2454. *Mercedes Carriage.* (Horseless Age, 8. pp. 431–432, Aug. 21, 1901.)—This is a powerful car, built with the centre of gravity as low as is practicable without bringing the mechanism dangerously near the road surface, and intended for general touring purposes. The engine is of the four-cylinder "Daimler" type, and is mounted near the front of the underframe. It is covered by a rectangular bonnet, which, at its front end, fits around the

[1] Electric automobiles are described in the section dealing with electric traction.

combined water-tank and radiator. This tank is 3 inches deep, and is honeycombed with small tubes from front to back. Behind the tank is a fan, driven by gearing from the engine shaft, so that a definite volume of air is sucked through the cooling pipes, irrespective of the speed of the car. The exposed surface of the air-pipes is very large, and the quantity of water carried, 1·5 gallons, is much less than is required with other forms of coolers. The water is circulated by a centrifugal pump. The engine is fitted with low-tension electric ignition supplied with current by a magneto machine. The power is transmitted to the change-speed gear through an expanding clutch, which forms part of the engine flywheel. The change gear is of the spur-wheel type, in which the wheels are engaged by side contact, and gives four forward speeds and one reverse. The transmission from the change gear is first by a bevel drive to the differential cross-shaft, and then by chain drives to the road wheels. Three powerful brakes are provided. An illustration is given of a 35-h.p. Mercedes car built on similar lines to the 16-h.p. vehicle.

C. R. D'E.

2455. *Musker Coke and Oil Fired Waggons.* (Automotor Journal, 5. pp. 518–525, Aug. 1901.) [See also Abstract No. 943 (1901).]—This paper gives an illustrated description of both types. In the former the boiler is placed in the extreme front, and is of the vertical Serpollet tube type, designed to generate superheated steam at 225 lbs. working pressure. The tubes are in concentric coils, and have an area of 70 square feet, with a grate area of 2·5 square feet. Coke is fed in through a hopper in the top of the boiler casing. Both a steam-jet and a centrifugal fan are employed for producing a forced draught. The engine has four horizontal cylinders, and is mounted a little in front of the back axle. Transmission is by spur gear to a countershaft parallel with the axle, and from this by internal spur gears to the road wheels.

The oil-fired waggon is constructed on much the same lines, except that the boiler is horizontal, and placed below the waggon platform. It is of the same type as the coke-fired boiler, but the supply of oil, water, and forced draught is obtained from a separate engine. In both waggons the wheel base is 10 feet, and gauge 5 ft. 7 in. The steering-wheels are 3 feet in diameter, with 5-inch iron tyres; the driving wheels 3 ft. 3½ in. in diameter, with 6-inch tyres.

C. R. D'E.

2456. *Motor Reaping Machine.* **G. Coupan.** (Génie Civil, 39. pp. 281–283, Aug. 31, 1901.)—This is a self-propelled field reaper, in which a petrol motor is employed to give motion both to the cutting-blades and to the vehicle itself. It consists of a three-wheeled truck, steered by the front wheel and driven by the rear wheels. The engine has two horizontal cylinders mounted nearly opposite one another, with pistons coupled to cranks at 180° on a transverse shaft lying between the cylinders. The engine is placed longitudinally between the axles of the truck, and the operator sits somewhat behind the rear axle, much as in a horse-drawn reaper. Below the cylinders is a long cylindrical box divided into three compartments. The central space contains the petrol supply, and the end compartments form the exhaust silencers. At one end of the crank-shaft is an overhanging flywheel, and at the other end is a bevel pinion, gearing with two bevel wheels on a downwardly inclined shaft. By means of friction clutches, either bevel gear may be caused to drive the shaft, giving motion to it for either forward or backward movements of the machine. At the lower end of the inclined shaft is a

bevel pinion, engaging with a bevel wheel on a horizontal shaft parallel with the length of the machine. From the back end of the horizontal shaft, motion is imparted to the driving axle through both a bevel and a spur drive, and at its front end an eccentric pin gives a reciprocating motion to the reaper blades. Suitable means are provided for driving either the reaper blades alone or propelling the machine alone. Several good illustrations of the mechanism are given. C. R. D'E.

2457. *Santos-Dumont Navigable Balloon.* (Engineer, 92. pp. 89–91, July 26, 1901.)—A general account of M. Santos-Dumont's experiments with navigable balloons is given, together with some details of his most successful air-ship. The balloon of the latter is of cigar shape, 34 m. long and 5·6 m. in central diameter, and has a capacity of 550 cubic metres. From it is suspended a triangular-shaped frame about two-thirds the length of the balloon, and constructed of pitch-pine laths stayed by steel wires. A 16-h.p. four-cylinder Buchet petrol motor is slung from the frame near the centre of its length, and drives, by a spur gear, a long tail shaft which carries at its far end a two-bladed propeller. The speed of the engine is about 2,000 r.p.m., and that of the propeller-shaft about 200 r.p.m.; the blades of the propeller are each 2 m. long. A three-cornered sail mounted over the propeller end of the frame is used for steering. The weight of the balloon is 150 kilos., and that of the rest of the apparatus 210 kilos. The speed attained in still air is about 11 m. per sec. Photographs are given showing the complete air-ship and the motor, together with a portion of the frame. C. R. D'E.

2458. *Brennan Engine.* (Horseless Age, 8. pp. 318, July 3, 1901.)—This is a horizontal petrol engine with cylinders mounted on opposite sides of an oil-tight crank chamber, and pistons coupled to cranks at 180°. The cylinders are of 3·25-inch bore × 4-inch stroke, and are water cooled. The body and head of each cylinder are made in one casting, so that there is no danger of leakage of water into the combustion chamber. The suction and exhaust valves work horizontally, and both open into the same valve box. The engine is rated at 5·5 b.h.p. at 1,400 r.p.m. A part sectional plan is given. C. R. D'E.

2459. *Sturtevant Carburettor.* (Locomotion Automobile, 8. pp. 488–489, Aug. 1, 1901.)—In this carburettor the surface of a metal drum, which rotates within a closed box, is kept moist by contact with an absorbent packing saturated with petrol. Air sucked in by the engine passes over the surface of the drum, and in this manner becomes carburetted. The richness of the carburetted mixture may be varied by varying the speed of rotation of the drum. C. R. D'E.

2460. *Le Croissant Electric Ignition.* (Locomotion Automobile, 8. pp. 550–551, Aug. 29, 1901.)—In this apparatus a combined magneto generator and induction coil is employed in conjunction with the ordinary form of high-tension sparking plug on the engine. The magneto has a permanent magnet field in the form of a ring with two projecting poles. Within the ring rotates an electromagnet having two coils at 180°, each coil consisting of a primary and a secondary winding. The primary coils are normally short-circuited, but once in each revolution the circuit is broken by means of a cam switch on the armature spindle. At the same time a second rotary switch establishes connection between the high-tension end of the secondary and the insulated terminal of the sparking plug, the low-tension end of the secondary being

always connected to earth. The charge in the motor cylinder is fired by the discharge between the points of the plug. The instant of ignition, relative to the position of the piston, may be varied by displacing the field magnet poles relatively to the armature. A diagram of the apparatus is given, and also a photograph showing its application to a motor tricycle. C. R. D'E.

2461. *Heymann Variable Transmission Gear.* (Horseless Age, 8. pp. 452–453, Aug. 28, 1901.)—In this gear the driving shaft has mounted upon it three eccentrics, arranged at 120° with each other, and so mounted that the throw of each can be varied between definite limits. These eccentrics drive a parallel shaft through roller clutches, which drive normally in one direction only, but may be caused to drive in the reverse direction. The angular movement of the driven shaft, per revolution of the driving shaft, is variable according to the eccentricity of the eccentrics. A photograph of the gear is given. C. R. D'E.

2462. *Brakes for Automobiles.* **A. Petot.** (Comptes Rendus, 133. pp. 410–412, Aug. 26, 1901.)—The author considers that in calculating the retardation produced by brakes, it is unnecessary to take into consideration the effect of the *vis viva* of rotating masses, such, for instance, as armatures on electric automobiles. The work which has to be done by the brakes is undoubtedly increased by the action of the rotating masses, but at the same time the pressure which can be applied by the brakes without causing skidding is similarly increased. The result is that the rate of retardation is the same as if the existence of the rotating masses were neglected. W. H. S.

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2463. *Alcohol for Automobiles.* **L. Guillet.** (Locomotion Automobile, 8. pp. 465–466, July 25, and pp. 481–482, Aug. 1, 1901.)—These papers contain a review of the possibilities of alcohol as a substitute for petrol in internal combustion engines. C. R. D'E.

2464. *Automobile Trials at Glasgow.* (Automotor Journal, 5. pp. 559–577, Sept. 1901.)—Judges' awards and descriptions of competing vehicles.

GENERAL ELECTRICAL ENGINEERING.

2465. *Temperature Increase of Accumulator Capacity.* **C. Heim.** (Elektrotechn. Zeitschr. 22. pp. 811–815, Sept. 26, 1901. Abstract of a paper read at the ninth annual meeting of the Verband Deutsch. Elektrotechn. at Dresden.)—The author confirms his previous observations of the increase of capacity of storage cells with rise of temperature [see Abstract No. 220 (1901)]. He has experimented with Hagen cells of 69 and 432 ampere-hours capacity. In the case of the smaller cells, heating was effected by a leaden worm, having hot water circulating through it, placed under the cell. The larger cells, which were in lead-lined boxes, were heated by gas-burners placed directly beneath them. To prevent loss of heat a felt jacket was placed round the cells. The result of the new experiments show that the influence of temperature on capacity is very marked. This result may be of practical importance if a rise of temperature does not injure the plates. W. W. H. G.

2466. *Discharge of Accumulators.* **S. A. Montel.** (Centralblatt Accumulatoren, 2. pp. 233–235, Sept. 1, 1901.)—A mathematical investigation of the relation between capacity and discharge current leads to the formula—

$$C = \frac{\gamma}{1 + \alpha I},$$

where C is the capacity, I the current, α and γ constants. This corresponds with the empirical formula of Liebenow. W. W. H. G.

2467. *Puncture Resistance of Insulators.* **C. Baur.** (Electrician, 47. pp. 758–759, Sept. 6, 1901.)—The curves relating to cables insulated with impregnated jute for thicknesses d of the insulation from 2 to 24 mm., and the corresponding potential V, can be represented by the formula $V = Cd^{\frac{2}{3}}$. The same formula was applied to curves representing a test made upon impregnated calico, measured between plain surfaces. Not only was the formula for the curve the same, but the constant was the same. For air, similar results with a different constant were obtained. O'Gorman [see Abstract No. 1574 (1901)] suggests a constant volt-resisting quality per centimetre, quoting Trowbridge and Gray, but the author finds that the puncture distances for 7, 8, 9, and 10 mm. are proportional to the numbers 52, 50, 48, 47. The curves quoted in O'Gorman's paper for Fuller board and empire cloth are also brought to agree, and a law is enunciated as follows : Every dielectric, whatever its thickness, requires a certain voltage to break it, and this is proportional to the two-thirds power of its thickness. Electrical breaking strengths, *i.e.*, p.d.'s necessary to break a thickness of 1 mm., are tabulated from this law as follows :—

Impregnated jute	2,200	volts.
Impregnated calico	2,200	,,
Dry ordinary air	3,300	,,
Vulcanised indiarubber of good quality	10,000	,,
Empire cloth	12,500	,,
Fuller board	19,000	,,
Mica	58,000	,,

M. O'G.

2468. *Design of Switch Gear.* **W. E. Warrilow.** (Elect. Rev. 49. pp. 381–382, Sept. 6; and 422–423, Sept. 13, 1901.)—The author points out that, with boilers or generating plant, breakdowns are generally confined to the units themselves; whereas with a switchboard a breakdown, such as a fire, may mean the total interruption of supply. It is therefore most necessary that every attention should be given to switchboard design, especially for the large power schemes which are now coming forward. A number of details in connection with high- and low-tension switchboards are given, and the author appears to come to the conclusion that the best solution is to be found in the pigeon-hole type of board, with no connections at the rear. E. K. S.

2469. *Lead Burning with Compressed Oxygen and Hydrogen.* **L. Michaelis.** (Zeitschr. Elektrotechn., Wien, 19. pp. 460–461, Sept. 22, 1901.)—After pointing out the danger of using certain types of oxy-hydrogen blowpipes, the author strongly recommends the safety burner made by the firm of H. Dräger of Lübeck [see also Abstracts Nos. 2484 (1900) and 1777 (1901)]. W. W. H. G.

2470. *Automatic Transformer Switches and their Effect on the Efficiency of Alternate-Current Systems.* **J. F. Weyde.** (Zeitschr. Elektrotechn., Wien, 19. pp. 441–445, Sept. 15, and 453–460, Sept. 22, 1901.)—After a general discussion of the house-to-house and substation systems of distribution, the author shows that a marked reduction in the all-day losses can only be effected by the adoption of automatic switches for throwing transformers into or out of circuit. He lays down the conditions which must be fulfilled by a satisfactory transformer switch thus: (1) the switch must be perfectly automatic in its action; (2) it must be capable of being applied to existing systems of distribution without necessitating any changes in the wiring on the consumer's premises, or in any way inconveniencing or hampering the latter in the use of his current-consuming devices; (3) the action of the switch must depend solely on the demand for current (time-switches are excluded by this condition), in order to secure the highest degree of economy; (4) the switch must be absolutely reliable, must absorb a negligible amount of energy, require little attention, and its first cost must be so low that, after deducting the 10 per cent. for interest and depreciation on the capital expenditure, a clear saving is still effected. The author states that out of the many automatic switching systems proposed there are only four which may be regarded as capable of being applied in practice. These are due to H. Müller; the Electric Selector and Signal Company of New York; Walton; and Schlatter. [See Abstracts Nos. 196 and 334 (1898).] The latter switch is, in the author's opinion, the only one which fulfils the conditions laid down by him. A detailed description of the switch and its mode of action is given. A. H.

REFERENCES.

2471. *Electromagnetic Mechanisms.* **S. P. Thompson.** (International Electrical Congress at Paris, Reports, pp. 201–209, 1901.)—This paper contains a discussion of the principles of classification of electromagnetic mechanisms as set forth by the author in 1887 in his treatise on the Electromagnet, and a detailed classification reproduced, with some modifications and additions, from that work. G. W. DE T.

2472. *Engineering Progress.* **R. E. Crompton.** (Electrician, 47. pp. 842–845, Sept. 20, 1901.)—Presidential address, chiefly on electric traction, delivered to Section G. of the British Association at Glasgow, Sept. 12, 1901.

GENERATORS, MOTORS, AND TRANSFORMERS.

2473. *Construction and Systematic Manufacture of Alternators.* **O. Lasche.** (Engineering, 72. pp. 173–174, Aug. 9; 205–207, Aug. 16; 240–242, Aug. 23; and pp. 277–280, Aug. 30, 1901. See also Zeitschr. Vereines Deutsch. Ing. 45. July 13 and 20, 1901.)—A very closely reasoned series of articles by an engineer of the A. E. G., in which he traces the development of alternator design from the small machines of ten years ago to the largest flywheel types of to-day.

Many very interesting particulars are given, but the drift of the whole paper is to show that for large sizes of machines it is impossible to continue the old method of building up alternator armature cores inside a massive cast-iron ring.

A round body of large diameter, when brought from an horizontal to an upright position, becomes changed in form by the action of its own weight. It has therefore been found better to build the armature rings of comparatively light weight and of standard section, and to depend on tie rods arranged outside the armature ring to give the necessary stiffness.

Besides giving a better mechanical construction from the point of view of getting the armature ring into a true circle, and keeping it in that condition whatever the temperature, there are a number of contingent advantages. Thus the machine is considerably cheaper and much easier to build. There is a considerable saving in carriage because of the reduced weight, and, inasmuch as the method allows of standardisation being carried to a higher degree than heretofore, the date for delivery of any given machine can be much advanced.

To show the very great saving in weight, a comparison is made between a large Westinghouse flywheel alternator and one built up on the tie-rod system. The weights of the armature ring are approximately as follows :—

	Rigid Cast-iron Casing Tons.	Stiffened Casing. Tons.
Weight of laminated iron in the armature	40	40
Additional constructional weight ...	195	10
Total weight of stationary part ...	235	50

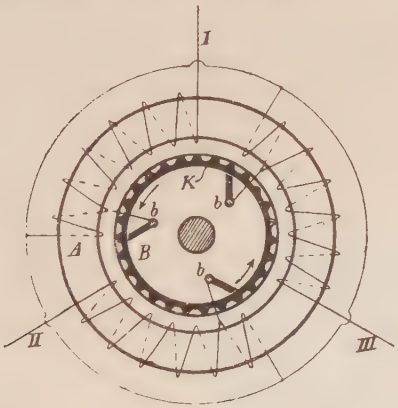
That is to say, in the first case the total weight is about six times greater than is electrically necessary. The articles are excellently illustrated. E. K. S.

2474. *The Compensation of Alternators.* **S. Woodfield.** (Elect. Rev. 49. pp. 343–345, Aug. 30, 1901.)—It is important that the terminal p.d. of alternators should be automatically so controlled as to be constant for all values of the load and for all power-factors. The usual method of compensating is to compound the alternator, the exciting coils receiving rectified current from a commutator. This method, however, fails to compensate for the demagnetising effect of the armature current when the load is inductive, and, in addition, the brushes need to be moved to the position of minimum sparking. The General Electric Company, of Schenectady, have devised a method of control which gets over these difficulties. Its application to a three-phase machine is described. The exciter is mounted on the shaft of the alternator, and has the same number of poles. In addition to being

connected to the commutator, the armature winding of the exciter is connected to three slip-rings, just like an ordinary three-phase rotary converter. The slip-rings are connected to the secondary terminals of a three-phase transformer, the primary windings of which are each in a main circuit of the three-phase machine. It is shown graphically that by this means compensation for all loads and power-factors can be obtained.

A. R.

2475. *Induction Motor with a Power-Factor of Unity.* **A. Heyland.** (Elektrotechn. Zeitschr. 22. pp. 633–634, Aug. 8, 1901; see translation in Electrician, Aug. 16, 1901.)—The author describes a method of increasing the power-factor of an induction motor, which is illustrated in the accompanying sketch, and which consists in producing the rotating field by means of low-frequency rotor currents. Imagine an ordinary induction motor with a short-circuited



rotor, and let the short-circuiting ring be provided with three brushes, as shown in the sketch, connected to small sections of the stator winding. The low-frequency currents led into the rotor windings through these brushes supply the necessary excitation. An ordinary squirrel-cage rotor would be unsuitable, as, on account of the low resistance of the short-circuiting ring, too much current would be shunted by it. The short-circuiting ring must have a suitable amount of resistance, and the arrangement used in practice would consist of a wound rotor, connected to a commutator whose segments are bridged over by suitable resistances, and which is therefore not liable to spark. The author states that not only may the power-factor be made equal to unity by means of this arrangement, but that the stator currents may become leading instead of lagging ones. The necessary adjustment is obtained by shifting the position of the brushes. A machine constructed on this principle will also act as a self-exciting generator, and the author expresses the opinion that such generators will be especially suitable in the case of large slow-speed machines intended for parallel running. Various machines of this type are in course of construction by the Allgemeine Elektricitäts-Gesellschaft, and by Siemens and Halske. A. H.

2476. *Graphical Theory of Synchronous Motors.* **P. M. Verhoeckx.** (Écl. Électr. 28. pp. 399–401, Sept. 14, 1901.) — The author criticises a paragraph in Blondel's paper on the graphical theory of synchronous motors [see Abstract No. 2010 (1901)]. He points out that the construction given by

Blondel to determine the wattless current of a synchronous motor working at constant power, as a function of the excitation, is not correct. A neat geometrical solution of this problem is given for the case when the armature reaction is negligible. In his reply (Ecl. Élect. 28. p. 482, Sept. 28, 1901), **Blondel** shows that the error was merely a slip in the title of the paragraph, which should read "at constant watt current," and not "at constant power."

A. R.

2477. *Calculation of Short-Circuit Current of Induction Motors.* **A. Siewert.** (Elektrotechn. Zeitschr. 22. pp. 615–620, Aug. 1, 1901.)—The method used by the author for calculating the current taken by the stator winding of an induction motor, whose rotor is short-circuited and prevented from running, is based on the following considerations :—When the rotor is open-circuited, the stator current must give rise to a magnetic flux, which is sufficient to produce a counter e.m.f. equal to the impressed p.d. This current may be calculated by determining the reluctance of the main path open to the magnetic flux—that through the rotor core. The reluctances of the leakage paths are in this case practically infinite, in comparison with that of the main path, and need not, therefore, be considered. When the rotor is short-circuited, the magnetic flux produced by the stator current must again be sufficient to give rise to a counter e.m.f. equal to the impressed p.d. But now the path through the rotor core is, by the action of the rotor currents, practically closed to the stator flux. Hence this flux has to pass entirely along the leakage paths, and in consequence of the high reluctance of these a much larger current will be taken by the stator. This current may be calculated, just as in the first case, but now the reluctance is that due to the leakage paths. The author divides these paths into (1) those across the stator slots ; (2) those through the air-gap from one stator tooth to another ; (3) those along the tops of the rotor teeth, and across the slits between the upper expanded portions of the teeth. A detailed calculation is given for several typical cases. The differences between the calculated and observed values of the short-circuit current amounted to from 5 to 10 per cent. A. H.

2478. *Alioth Three-phase Asynchronous Motors.* **L. Trylski.** (Écl. Électr. 28. pp. 322–325, Aug. 31, 1901.)—This is an illustrated description of one of the Alioth three-phase motors manufactured for the "Compagnie des chemins de fer de l'Ouest."

The motors can develop 500 h.p. at a speed of 100 r.p.m. The pressure is 5,000 volts, and the frequency 25. The diameter of the rotor is 2,996·5 mm., and the air-gap is 1·75 mm. all round. The stator winding is placed in 450 slots, and is composed of 225 coils placed in micanite tubes. The rotor is drum-wound, with 30 poles, the winding being placed in 720 slots.

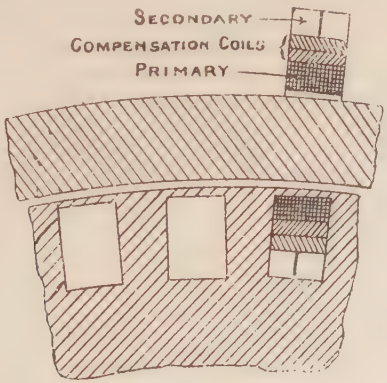
The current taken by the motor is about 50 amperes, the efficiency is 92 per cent., the power-factor is 0·93, and the slip on full load 3 per cent.

W. G. R.

2479. *Static Transformers.* **J. Routin.** (International Electrical Congress at Paris, Reports, pp. 105–137, 1901.)—In this paper the author considers the following problem :—Given the dimensions of the magnetic framework of a transformer, and the weight of copper in the windings ; to determine the effects of varying the induction upon the no-load loss, the ohmic drop in voltage, the efficiency, and the heating of the different parts. He first gives an easy mathematical proof, in the case of the two windings of

a monophase transformer, of Kapp's law, that, with a given C^2R loss, the least quantity of copper will be required when the current densities are the same in the two circuits, and points out that, in addition to the economy, the fulfilment of this condition gives the advantage of distributing the losses approximately in proportion to the cooling surfaces of the two windings. He then shows that the same law holds for any number of circuits. As a special case it follows that for a given C^2R loss in any network, the greatest economy in copper is obtained when the current density is the same throughout. The author then obtains a series of curves, expressing the different quantities considered in terms of the induction, and, after showing by their aid that the best results in practice are not obtained under the theoretical conditions of maximum efficiency, he determines in the first place the relations existing between the various quantities. He then establishes the relation between the heights of the cores and the distances between them for a minimum hysteresis loss, considers the effects of varying the dimensions of the framework and of the core sections, and finally, he investigates the best form to be given to the core sections, arriving at the conclusion that the stampings should be cruciform, the arms being of equal length, and the section a maximum determined by the condition that it has to fit into the cylindrical space within the winding. Illustrations are given of transformers manufactured by Grammont to the author's design. G. W. DE T.

2480. *Rotary Converter by Leblanc.* **C. Feldmann.** (Elektrotechn. Zeitschr. 22. pp. 806–811, Sept. 26, 1901.)—The paper contains a fully illustrated description of a 60-kw. Leblanc converter [see Abstract No. 505 (1899)] for two-phase currents. It consists of a transformer whose secondary



coils are connected to a stationary commutator, and a small synchronous motor for rotating the brushes inside the commutator. The core of the transformer is formed by two laminated coaxial rings, the inner one of which is furnished with 60 slots, in which the coils are arranged as shown by the sketch. The 60 secondary coils are connected to the commutator, which contains 480 segments, the segments being connected by means of cross-connectors. The compensation coils are intended to facilitate sparkless running, by supplying the wattless components of the current to a synchronous motor. An elaborate theoretical discussion of this mode of transformation is given by the author, who states that the practical results obtained with the machine described are in complete accord with theory. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2481. *Pole Line Construction for High-Pressure Transmission.* **C. O. Poole.** (Journal of Electricity, S.F., 11. pp. 185–195, Aug., 1901. Paper read before the Pacific Coast Electric Transmission Association, San Jose, June, 1901.)—In this paper, which is very fully illustrated, the author gives an account of the system of pole line construction adopted by the Standard Electric Company of California. The poles are of sawn redwood without sap, and vary from 30 feet high, 7 inches square at the top and 12 inches at the base, with 5 feet below ground, up to 60 feet high, 11 inches square at the top and 17 at the base, with 8 feet below ground. In soft, marshy ground a sort of Maltese cross arrangement of redwood arms, 8 ft. × 8 in. × 2 in., is spiked on so as to come just below the surface with about 3 feet of turf and earth piled over it. At all angles greater than 2·5° the poles are double constructed and strutted. A truck derrick is used for erection where possible. In very bad ground from one to three piles support each pole. Where supported over water, platforms 4 feet square are built round the bases for construction and repairs. When crossing navigable streams, in order to attain the statutory height of 115 feet above high water, steel towers with redwood tops are employed. The greatest span is 618 feet, with a sag of 19 feet. The cable strains are taken on four to six insulators attached to horizontal arms shaped to the curve of the cable to divide the strain. The main line consists of three aluminium cables, each $\frac{7}{8}$ inch in diameter, and made up of 37 strands. The weight per mile is 2,404 lbs., and the resistance per mile 0·205 ohm. It is laid right and left hand, and has a tensile strength of 28,000 lbs. per square inch. The factor of safety is 7 at 20° F. Owing to the high coefficient of expansion of aluminium, a 132-feet span, having a sag of 33 inches at 100°, will have perhaps only 13 inches on a cold morning. No. 1 solid aluminium wire is used for tying the large cables, and No. 4 for cables not exceeding 0·5 inch in diameter. The joints consist of right- and left-hand screw sockets, conical-shaped, with the centre or core wire of the cable turned back on itself, forced into the socket, and tightened by driving in a tapered aluminium plug. Their resistance is below that of the ordinary portions. Two-part insulators are employed, the upper half being of porcelain, which resists moisture better, and the lower half of glass, which has a greater dielectric strength. They are tested for five minutes at 120,000 volts, obtained by twelve 10,000-volt transformers. Two men can test thirty insulators in fifteen minutes. The transformers are connected in groups of three on the low-tension side through insulating transformers, the high-pressure terminals being all connected in series. The pressure is regulated by a rheostat connected in series with the low-tension circuit. The insulator pins are of blue gum sawn into sticks, cleared of sap by boiling, and air dried, after which they pass through a machine which completes the pin in one operation, and finally they are boiled in linseed oil. The pins are driven into the pin-holes with paint simply. A porcelain sleeve covers the base of the pin and projects up under the glass petticoat, an arrangement which prevents weathering, and protects the pin in case of an arc tending to strike from the edge of the insulator to the base of the pin. The cross-arms are of close-grained kiln-dried Oregon pine, treated with asphaltum oil under pressure at a

temperature of 250° F. until thoroughly permeated. All poles carry a six-pin telephone arm placed 6½ feet below the power arm. The power line is not transposed, but the telephone wire is transposed every four poles on a single transposition insulator. Provisions are made for opening the power line at several points, in case of trouble, by means of switches contained in specially designed switch-houses. G. W. DE T.

2482. *High-Tension Switches and Fuses.* (Journal of Electricity, S.F. 11. pp. 176–180, July, 1901.)—This is a report of the discussion on the eleven papers on high-tension switch gear read before the Pacific Coast Electric Transmission Association. [See Abstract No. 1996 (1901).] **C. O. Poole** thought that extremely high-tension switching should be done in oil or water. **Masson** said that the Independent Electric Light and Power Company always made a point of opening and closing all high-tension switches when there is power on both sides of the switch, so that there is no spark. The shock or stress on the insulation of the system that is produced by a spark is a bad thing, and while it is certainly possible to make a switch that will open any circuit, provided the building is big enough or oil is used, yet it is much better to arrange the switch gear so that there is no arcing at all. No matter whether an arc is broken in air with a gap of 6 feet in a long flaring arc, or in oil with a gap of 3 inches, there still results a most serious shock to the insulation. He advocates in all cases, therefore, the closing of low-tension switches first, and then of the high tension. In illustration of his argument he described an arrangement in which two or more polyphase generators can be connected through multiple switches to a set of bus-bars, and through transformers, with multiple switches in the primary circuits, to the distributing bus-bars, these being closed first. If the generators are then connected with their bus-bars they will be held in parallel. The two machines being also held in parallel from the low-tension side, there will be no p.d. on opposite sides of the high-tension switches, which may therefore be closed or opened without any sparking. He spoke strongly against the habit of opening switches occasionally to see if they were in proper order, and he also had a good deal to say against the use of circuit-breakers, which he described as very treacherous at best. They were liable to jar out in time, and the hair triggers were altogether too delicate. If they were employed they should be triple pole (one for each phase), not single pole. **Lighthipe** confirmed Masson's remark that with plenty of head-room one could open any circuit. The oil switches on the Metropolitan Railway open very heavy circuits at 5,000 or 6,000 volts—3,000 to 4,000 amperes. Each switch is confined in a brick fireproof vault and worked pneumatically by an attendant standing about 80 feet away. The arcing of a switch depends on the load, and whether it is opened at a certain critical part of the wave. One may open a break switch a dozen times and nothing occur, but, given suitable conditions at the thirteenth time, the effect will be serious. **Theberath** had found that the best way to open an oil break switch was to do it slowly, so as to give the oil a chance to dissipate the arc before getting too much distance between. On opening a switch quickly he had found the contact points burned slightly, as the oil had not had time to get in between the contact points. When the switch was opened slowly the contacts were saved absolutely—there were no indications of any burns. **Poole** pointed out that from experiments he had made with special transformer oil and switch oil, something other than oil must be used as the liquid for breaking arcs on extremely high voltages; he had found that at 28,000 and

34,000 volts the oil is carbonised very rapidly so that black streaks can be seen across it. **Sterling** called to mind a switch at Montreal in which compressed air was used. It not only broke the arc suddenly, but had the advantage of cooling off the contacts, and thereby lessening the volatilisation of the metal feeding the arc. He thought that the switch of the future would be worked on those lines. E. K. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2483. *Keighley Electricity Works.* (Elect. Engin. 28. pp. 366–370, Sept. 13, 1901.)—This station supplies continuous current. It contains two Lancashire boilers 30 feet by 8 feet; two 120-kw. and one 200-kw. dynamo; a battery of 256 cells, giving 35 kw. for 10 hours; and the engine-room, which is 85 feet by 40 feet, contains a 10-ton travelling crane, the boiler-house being 85 feet by 70 feet, and the battery-room 53 feet by 26 feet. Two feeders have been laid, each consisting of three single cables; the conductors of the one set are 0·4, 0·15, and 0·4 square inch in section, and the others are 0·3, 0·1 and 0·3 square inch. W. H. S.

2484. *Los Angeles Transmission Plant.* (Elect. World and Engineer, 37 pp. 1113–1115, 1901.)—The Edison Electric Company of Los Angeles operates a 33,000-volt transmission line 83 miles long. The transmission lines are two three-phase circuits of No. 1 B & S wire on triple petticoat porcelain insulators. The line wires are 18 to 24 inches apart, but in future this distance will be increased to avoid short-circuits from birds. It was found necessary to have at least 10-kw. transformer capacity to satisfactorily test the insulators at 70,000 volts. No fuses are put in the high-tension line nor at the power-house, except that the generators are fused to four or five times their capacity. The power-house contains four 750-h.p., 50-cycle, 750-volt three-phase generators, direct-coupled to Pelton wheels operating under 728 feet head. Generators of this type connected to water-wheels do not give sufficient current on short-circuit to endanger their windings. In fog all the pole-tops become luminous, but the total power lost on the 83 miles is, at such times, less than 500 watts. Wirt lightning arresters are used, and have 48 $\frac{1}{16}$-inch gaps; there is a static discharge continuously between the gaps for about half the distance to ground, the other gaps being silent. Motor generators are strongly preferred to rotary converters for use with frequency as high as 50 cycles. The Siemens "horn" type of high-tension switch is used. A telephone circuit is carried 6 feet below the transmission line, and operates with entire success. [See also Abstract No. 923 (1899).] E. H. C.-H.

2485. *Isker-Sophia Power Transmission.* **F. C. Perkins.** (Journal of Electricity, S.F. 11. p. 182, July, 1901.)—Sophia is supplied with electric energy from a turbine plant on the River Isker, 20 km. distant. There are four turbines by Piccard, Pictet and Co., of Geneva, each of 500 h.p. at 400 r.p.m. Regulation is effected by hand, or automatically, as may be desired. The generators are directly connected with flexible insulating couplings, and they are insulated from the earth. The Maschinen-fabrik Oerlikon has provided the electrical plant. The generators are three-phase, of the revolving field type with 16 poles, $\sim$ 52, capacity 425 h.p. and power-factor of 0·8. The clearance is 5 mm. Six-pole direct-curre

machines mounted on the alternator shafts are used for excitation. At twelve substations the pressure is transformed from 7,200 volts to 165 volts for the outskirts of the city, whilst the central area is supplied from a main transformer, reducing the pressure to 3,500 volts, which is then transformed at five substations to the working voltage of 165. The street railways are also supplied from the same source. The high-tension line consists of three copper conductors, each 8 mm. in diameter. W. W. H. G.

2486. *High-Tension Three-phase Railway in the Valtelina.* **H. Martin.** (Génie Civil, 39. pp. 101–106, 1901.)—The Italian Southern Railway Company decided last year to adopt electric traction on their Adriatic lines, using accumulators where the traffic is light and a third-rail system where dense. On the 42 km. between Bologna and San Felice, accumulator trains have just been started; each bogie carriage, weighing 45 tons loaded, has two 50-h.p. motors, and three batteries of 94 cells each, and carries 60 people. With the three batteries in series and the motors in parallel, the speed on the level is 75 km. per hour.

The Valtelina lines (from Lecco to Chiavenna, with a branch from Colico to Sondrio) [see also Abstract No. 1377 (1900)] have been equipped with a third rail on the Ganz system, using 3,000 volts, three-phase, at the motors. The district served is essentially a manufacturing one, and there is also a large tourist element. The 60-passenger cars will carry motors to the amount of 300 h.p., and will weigh 50 tons, with 2 tons of luggage. They can draw four ordinary coaches up a 1 per cent. grade at 60 km. per hour, or up steeper grades at 30 km. per hour. Luggage trains will be drawn by 600-h.p. locomotives, weighing 50 tons, capable of pulling 200 tons of trucks up a 2 per cent. grade at 30 km. per hour.

The long distances between the stations minimise the drawbacks of the alternating system in starting and speed regulation. All metal on the cars, including the metal roof, is carefully earthed, and all apparatus is entirely metal-clad. For equal powers transmitted over the same distance, and with the same drop in voltage, the total weight of copper necessary with continuous current at 700 volts is ten times the weight required with 3,000 volts three-phase. Three hundred amperes is about the maximum current which it is practicable to take from a trolley, and 3,000 volts is therefore necessary for sufficient power to operate trains of the usual size. A device is provided to earth the 3,000-volt trolley wire directly its tension falls owing to breakage.

Energy is supplied from a water-power plant at Mortegno on the Sondrio branch, where three 2,000-h.p. turbines are direct-coupled to alternators generating three-phase current at 20,000 volts and a frequency of 15. The transformation to 3,000 volts is effected in nine substations along the lines, whence are fed the two trolley wires, each 8 mm. in diameter, supported by porcelain insulators from brackets or span wires.

Each motor car carries four motors directly, but flexibly, connected to the axles. At normal speed (60 km. per hour), two motors alone are in circuit, receiving direct in their fixed field coils three-phase current at 3,000 volts. The two other motors are only used in starting and stopping and on grades exceeding 1 per cent., when they are connected "in cascade" with the high-tension motors, *i.e.*, the current induced in the armature of the high-tension motor is led into the field of the low-tension motor, whose armature is in turn connected to a liquid resistance. The transformation ratio in the high-tension motor is such that its armature voltage is 300 volts. In cascade, the speed of the train is halved.

The motor cars have bodies 18·10 m. long and 2·70 m. wide, resting on two bogies whose wheel base is 2·5 m., and whose truck is 4·1 m. long, and is supported from the axle-boxes by ordinary plate springs. The pivots and frame for the body are further supported by two groups of three double springs. The bogie pivots are 11·5 m. apart.

The two trolley wires over each track are tapped by a special form of double trolley consisting of two copper rollers separated by an insulating block of wood. The trolley arm is raised into contact by a piston actuated by compressed air. The rollers make contact with carbon brushes connected to flexibles. Each car has a double trolley at each end, *i.e.*, 12 m. apart, so that dead sections (which never exceed 7 m. in length) can always be spanned. If the trolley jumps the wires or otherwise rises above the normal level it automatically opens an air valve which lowers it.

The cables from the trolley bases to the apparatus on the cars are rubber-insulated, supported in cylindrical porcelain insulators placed every 10 cm. inside brass tubes, which are carefully connected metallically to the wheels and the roof, &c., to insure immediate blowing of fuses in case of leakage. From a distribution box in the operator's cabin circuits are taken through fuses and à primary switch to the motors, and to an 8-kw. transformer supplying current to a motor which compresses the air, and lights, heats, and ventilates the car. The primary switch consists of a horizontal iron plate pivoted on a vertical shaft ending in a rack in which engages a pinion worked by a hand crank. Turning this crank raises the plate, which has on its upper side six porcelain-backed metal bolts with steatite heads. These bolts are vertically below six copper sockets sunk in porcelain insulators, three sockets being connected to the motors and three to the collecting apparatus. The bolts enter the sockets with slight pressure, and when withdrawn cause a little rarefaction of the air, which opposes the formation of an arc, which is further prevented by the steatite heads. Reversal of the current to the motors is effected by simple rotation of the lower switch-plate around its vertical axle. A relay in the return circuit to the rails lowers the switch-plate if the current to the motors exceeds the safe limit.

Each bogie truck has a high-tension motor on one axle and a small low-tension motor on the other axle. The large motor will give 150 h.p. at full speed. The armature shafts are hollow, and are threaded over the axles, to which they are connected by springs forming an elastic coupling.

The 3,000-volt current goes only to the main motor fields, and the sole operation which has to be done with it is the closing and opening of the primary switch. All regulation is performed on the low-tension induced current by a two-point controller, putting the motors in cascade or otherwise, and an air valve which regulates the height of liquid in the rheostat. The rheostat consists of a series of small sheets of iron up which an alkaline solution is forced. When the liquid reaches the top, a float operates an air valve, which works a switch short-circuiting the three legs of the armature winding. There are two rheostats per car. All high-tension apparatus is in a locked case, the key to which is inaccessible as long as the trolley is raised.

The air compressor for the whistle, brakes, and controlling gear is worked by a 5-h.p. three-phase motor at 100 volts. An automatic brake is provided, so that when current fails the train is at once pulled up. This will work when an overhead wire is broken or when a section is intentionally made dead to prevent the train passing, thus forming an effectual block system.

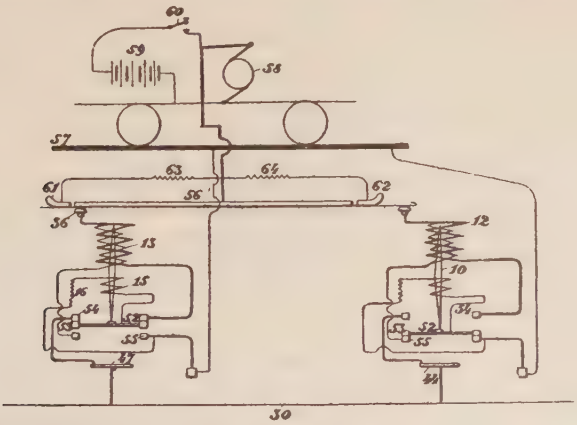
E. H. C.-H.

2487. *Lincoln Power Station, Boston, Mass.* (Eng. Record, 44. pp. 147–151, Aug. 17, 1901.)—The *boiler-room* contains twelve Babcock and Wilcox boilers in batteries of two each. Each boiler is rated at 500 h.p. at a pressure of 200 lbs. per square inch. The feed-water is heated by Green's economisers, after passing through exhaust heaters, and Webster secondary open heaters, placed beneath the stack. It enters the boilers at a temperature of 300°–325° F. Coal is raised to bins above the boilers by a conveyor, and is fired by Roney stokers. The *engine-room* contains two Rice and Sargent vertical compound engines of 4,000 h.p. at 75 r.p.m. with a steam pressure of 160 lbs. Their cylinders are 44 and 88 inches diameter, and 60 inches stroke. The flywheel weighs 120 tons. A third engine is being built by the Westinghouse Company of the same dimensions. Each engine exhausts into an independent Blake jet condenser. Each engine drives directly a 2,700-kw. direct-current generator giving current at 550-600 volts. One is by the General Electric Company, and the other by the Westinghouse Company.

Scale drawings are given of the constructive details of the power-house, of the coal bins, and of the main steam header. G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

2488. *Felice, Tosi, and Parboni's Surface-contact System.* **J. Reyval.** (Écl. Électr. 28. pp. 213–219, Aug. 10, 1901.)—The essential elements of this system are:—(1) Electromagnetic switches acting on the principle of the differential arc-lamp regulator, so that the gravity break is supplemented by an electromagnetic pull-off. The break takes place between carbon contacts



under heavy wood-tar oil, and each switch is enclosed in a moisture-proof iron case and is permanently connected to the positive main; (2) steel contact plates placed between the rails, each plate being permanently connected to its switch; (3) a contact skate having a short portion at each end insulated from the central part and connected through resistance coils to the motor circuit, the object of this arrangement being to diminish the sparking in the switches; (4) a small storage battery on each car for starting. The arrangements are shown in the accompanying diagram, in which 30 is the main feeder, 57 the rail, and 56 the skate. The system has worked well during a six-months' experimental trial in Rome. G. W. DE T.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

2489. *Signals on the Boston Elevated Railway.* **H. S. Knowlton.** (Street Rly. Journ. 18. pp. 155–159, Sept., 1901.)—This paper describes the various kinds of signals employed. On certain tracks automatic block signals are used, which apply the air-brake if the train runs past a danger signal; the signals are worked automatically by the train entering and leaving the block. G. H. B.

2490. *Testing Electric Automobiles.* **W. A. T. Müller.** (Centralblatt Accumulatoren, 2. pp. 209–211, Aug. 1, 1901.)—In this paper some equations are first deduced giving the connection between the turning moment and the current, using a series motor. An arrangement is then described for starting and stopping a stop-watch at the beginning and end of a measured distance, this being effected by means of an electromagnet in a circuit extending along the track. Currents are passed along this circuit by means of mercury switches formed by indiarubber tubes filled with mercury, over which the vehicle passes. C. K. F.

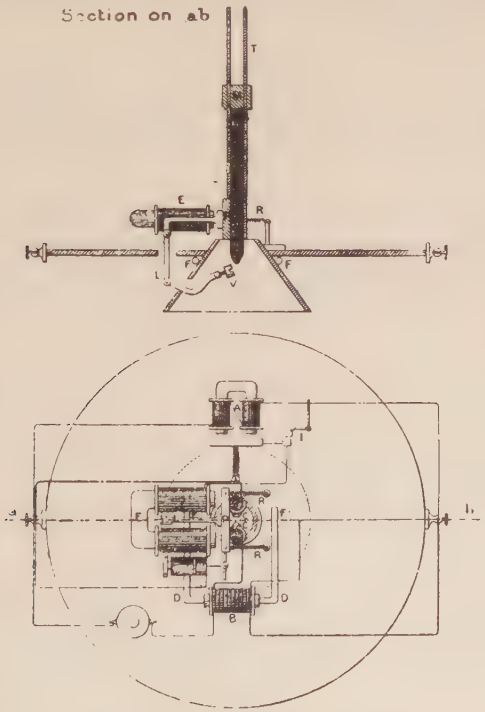
ELECTRIC LAMPS AND LIGHTING.

2491. *Progress in Electric Lamps.* **A. Blondel.** (International Electrical Congress at Paris, Reports, pp. 210–250, 1901.)—This paper consists of a valuable critical discussion of the difficulties overcome and the progress made, mainly during the last ten years—(1) In knowledge of the phenomena of the electric arc; in the construction of arc lamps, and the methods of supplying them with current; in the manufacture of arc-lamp carbons: the section concludes with a discussion of the luminous efficiency of arc lamps and methods of photometry. (2) In the theory and methods of manufacture of incandescent lamps; their efficiency; the various substances which have been tried for filaments, with special reference to the recent work of Welsbach, Le Roux, and Nernst; photometric methods and standards. G. W. de T.

2492. *Efficiency of Incandescent Lamps.* **G. V. Williams.** (West. Electn. 29. pp. 82–83, Aug. 10, 1901. Abridged from a paper read before the North-Western Electrical Association at Sheboygan, Wis., June 26, 1901.)—Actual tests show that lamps frequently consume far more than their rated power, if of normal candle-power; or, if the power is as stated, the candle-power is much below the value claimed for it. To detect these faults careful testing is advocated where lamps are renewed without charge. Attention is drawn to the importance of good pressure regulation, especially with high-efficiency lamps. The results of tests made by various supply companies are given, with life curves. Several batches of 220-volt lamps were found to have an average life of 750 to 930 hours without losing more than 20 per cent. of their rated candle-power, taking from 4·18 to 4·6 watts per candle. Lamps of lower voltage taking less than 3·5 watts per candle seldom appear to give satisfaction. A. H. A.

2493. *Bremer Arc Lamp.* **F. Laporte.** (Soc. Int. Élect., Bull. 1. pp. 360–370, July, 1901.)—This lamp [see Abstract No. 2117 (1900)] has its two carbons CC equally inclined on each side of a vertical line, and making an angle of 20° to 30° with each other. They are guided by tubes in which they slide, and heavy masses M resting on them ensure their descent. An armature P, whose pressure is regulated by springs R, touches the lateral surface of the two carbons through an opening in the tubes, and acts as a brake, so as to

stop their descent. An electromagnet E, when the current passes through it, pulls away this armature, and the carbons slip down. This armature governs at the same time, by means of the jointed levers L, a kind of pallet V, which takes a position at the apex of the angle formed by the two carbons, when the armature P is attracted by E, but is ordinarily kept out of the way by the action of the springs. The object of this pallet is to maintain the ends of the carbons always in the same horizontal plane. A shunt relay A, furnished with a contact I, makes or breaks the current in E, according as the potential difference of the arc is higher or lower than a fixed value. Finally, two differentially wound bobbins B (main and shunt) magnetise a core D with pole pieces F, placed on either side of the arc. The magnetic field thus produced is perpendicular to the plane of the two carbons, and has a direc-



tion so as to blow the arc down to the points of the carbons. All these parts are attached to a horizontal plate, which carries a conical reflector and supports the globe. Lighting is effected by the relay A, which sends the current through E and attracts the armature P, allowing the carbons to slip till they touch the pallet V, which is brought under them by the attraction of P to E. The potential difference on the lamp falls below its normal value, and the current through E is cut off by the relay breaking contact. The carbons are locked in their new position by P, and V is rapidly drawn away, striking the arc between the carbons. As the carbons are now very near together, the current is too large, so that the series winding of B prevails, and produces a strong field between the poles F, which blows the arc down in a pronounced curve below the carbons. As the carbons burn away, the arc lengthens and the main current diminishes; this diminishes the field between

the poles F, and the arc takes a less pronounced curve, thus becoming shorter. The carbons used in the lamp are a Siemens, series A, solid 6 mm. for negative, and a special 7 mm. cored carbon for positive. A gramme of this special carbon calcined in the air gives 0·28 gramme of residue composed principally of magnesia, aluminia, and silica. The lamp works at 9 amperes and 43 to 45 volts. Photometric measurements were made by the authors in this lamp, and comparison was made with an ordinary arc lamp, both with and without globes. The figures for the Bremer lamp without globe and with globe are respectively: Potential difference 45·2 and 45·9 volts; current 9·45 and 8·75 amperes; watts 427 and 400; luminus flux (lumens) 13,950 and 8,020; mean spherical candle-power, 1,110 and 638; mean lower hemispherical candle-power 2,220 and 950; watts per spherical candle-power 0·385 and 0·628; watts per lower hemispherical candle-power 0·192 and 0·421. E. C. R.

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2494. *Power Transmission in Utah.* **J. R. Cravath.** (Elect. World and Engineer, 37. pp. 503–508, 1901.)—Description of a transmission over 36½ miles at 16,000 volts. M. O'G.

2495. *Wiring Rules.* **F. Broadbent.** (Inst. Elect. Engin., Journ. 30. pp. 1130–1150; Discussion, pp. 1150–1158, Aug., 1901. (Abstract).)—The author protests against the excessive variety of regulations for electric lighting installations, issued by insurance offices and supply authorities, and advocates their reduction to a uniform standard. The various codes are compared with each other in detail, and are shown to be contradictory and inconsistent in the extreme. The main features of a large number of codes are given in tabular form. In the discussion, several speakers strongly corroborated the urgent need for uniformity in such regulations. A. H. A.

2496. *Electricity for Lighting and Motive Power in Theatres.* **L. Mornat.** (International Electrical Congress at Paris, Reports, pp. 281–286, 1901.)—The paper consists of an enumeration of the ordinary precautions to be observed in wiring and in the arrangement of the circuits. G. W. DE T.

2497. *Current Supply to Tramways.* **Postel-Vinay.** (International Electrical Congress at Paris, Reports, pp. 286–302, 1901.)—This paper consists of notes on early suggestions of electric traction and on the development of the trolley, with brief references to the conduit and surface-contact systems. G. W. DE T.

2498. *Overhead Line Construction.* **K. B. Thornton.** (Elect. World and Engineer, 38. pp. 61–64, July 13, 1901. Paper read before the Canadian Electrical Convention.)—Particulars are given of the length, size, and life of poles, their treatment and erection; also of cross-arms and insulators. Various methods are described of making dead-ends on a line. The erection of line wire and guys is dealt with briefly, and some figures of wind and other stresses are given. The protection of lines from lightning is discussed at some length. G. H. B.

TELEGRAPHY AND TELEPHONY.

2499. *Dredging for Cables in Deep Sea.* **H. Larose.** (Écl. Électr. 28. pp. 197–206, Aug. 10, 1901.)—The author considers the causes of failure to grapple the cable, which, in the instances quoted, and shown in tabular form, average over 50 per cent. of the attempts. He finds that the failures have been due chiefly to the use of too light a tow-rope, and too short a length of towage. He argues that, to keep the grapnel horizontal, and to permit the teeth to properly embed themselves in the sea bottom, and to drag through it continuously, the length of line paid out should be considerably more than the actual depth of the bottom from the ship. When the latter is proceeding at a slow rate, say 1 or 1½ knots, he finds that for a rope weighing 0·9 kg. per m. in the sea, the length for 1,000 m. depth should be 1,730 m., and for 2,000 m. depth, 2,830 m. line. A table is given showing the proportions to be observed for different depths. For lighter ropes a longer tow is required, as they tend to straighten out more easily, and lift the grapnel out of the horizontal position. He describes other causes of failure, such as jerking the grapnel over the bottom and the entanglement of the tow-rope in the teeth, where, in first paying out, the grapnel happens to stand upright, and he mentions that the "Centipede" and Rouillard's patterns overcome this difficulty. Experience shows that, at the slow speed of the vessel above mentioned, the resistance of the water to the motion of the tow-rope is negligible. E. O. W.

2500. *State Telephone-Exchange at Brussels.* (Elektrotechn. Zeitschr. 22. pp. 751–753, Sept. 12, 1901.)—At this exchange, which is arranged in the first place for 6,000 subscribers, there are complete metallic circuits and, for the most part, underground conductors, the system employed being that of the Western Electric Company with a central battery and glow-lamp signalling. The conduits for the underground conductors are constructed as follows: On the bottom of the trench is a layer of concrete 10 cm. thick, and then a thin layer of cement. Into this, the lowermost row of glazed earthen-tubes is pressed, the remaining rows being also laid in cement. These tubes are 460 mm. long, and have an internal diameter of 80 mm.; they were delivered at Antwerp at the price of 67 pfennig per metre and laid by the H. B. Camp Company, of Aultman, Ohio. The tubes of each conduit are centred by means of a mandrel 750 mm. long. At one end this mandrel bears a disc of indiarubber which fits the inner walls of the tubes fairly tightly and carries forward and pushes out all superfluous cement, dirt, &c. The cost per metre run is about the same as for cement conduits. Diagrams of the connections are given, and details of the method of working. C. K. F.

2501. *Telephone Wires on Power Line Poles.* **T. E. Theberath.** (Journal of Electricity, S.F. 11. pp. 168–170, July, 1901. Paper read before the Pacific Coast Electric Transmission Association, San Jose, June, 1901.)—After giving some examples of defective arrangements, the author gives it as his experience that the spiralling of the power wires is of more importance than the transposition of the telephone wires; and in the 60-mile line from the power-house to Sacramento the telephone wire was carried, without transposition,

5 feet below the three-phase power wires, which were arranged to form two circuits on the points of a hexagon with 2-foot sides, each circuit being given a third of a turn per mile, in opposite directions. With this arrangement any multiple of 3 miles is exactly balanced, and if the distance is known beforehand the spiralling can be arranged to give an integral number of turns. This not being so in this case, the last section, which was not exactly 3 miles in length, was divided into three. In the Bay Counties power line, 142 miles long, the end was left unbalanced, the effect, on account of the great length of the line, being negligible.

The telephone wire on the latter lines is No. 4 stranded aluminium cable for a distance of 80 miles, and three-strand aluminium cable for the rest of the distance. The insulators are of double-petticoat, double-groove glass, on two pins, equidistant from the pole, on a six-pin arm 5 feet below the power wires, which carry current at 40,000 volts connected with earthed neutral. When everything is in order the line is absolutely quiet, but becomes very noisy in the case of an earth on the telephone wires, as this reduces the telephone line to a single wire with an earth return.

G. W. DE T.

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2502. *Wireless Telegraphy between Borkum and Borkum Lightship. German Post Office Report.* **Jentsch.** (Archiv Post Tele. 8. pp. 251–262, 1901.)—This is a description of the work done by wireless telegraphy between the above-mentioned stations during the past year, with notes on difficulties met with and methods of overcoming them. A description of Slaby's system is also given. J. E.-M.

2503. *Wireless Telegraphy between France and Corsica.* **J. Blondin.** (Écl. Électr. 28. pp. 93–98, July 20, 1901.)—A concise description, with diagrams and illustrations, of the installation erected for the French Government by Marconi's International Communication Company. J. E.-M.

2504. *Guarini Automatic Repeater in Wireless Telegraphy.* (Elect. Rev. 48. pp. 871–872, May 24; 966–968, June 7; 1112–1119, June 28; and 49. pp. 43–45, July 12, 1901.) —Description of experiments.

2505. *Telephone Cables.* **W. Blackstone.** (Écl. Électr. 28. pp. 168–178, Aug. 3, 1901.)—These articles appear to be on the same lines as those referred to in Abstract No. 1304 (1901). It gives an account of the methods suggested respectively by Pupin, S. P. Thompson, and Reed for increasing the speed of signalling through cables. R. A.

2506. *Simultaneous Multiplex and Ordinary Telegraphy.* **E. Mercadier.** (Comptes Rendus, 133. pp. 472–474, Sept. 16, 1901.)—This paper describes the success of the system, as applied to the circuit betweeu Paris and Bordeaux, without disturbing existing arrangements, by which thirteen twenty-word telegrams can be exchanged hourly. The Mercadier system was described in Abstracts Nos. 1995 (1899) and 1388 (1900). E. O. W.

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The numbers refer to Abstracts, those in italics referring to References.

An asterisk indicates remarks in a discussion.

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In Light :—Absorption; Dispersion; Interference; Measurements and Use of Instruments; Miscellaneous; Phosphorescence and Fluorescence; Photography; Photometry; Polarisation; Rays and Radiation; Reflection of Light; Refraction of Light; Spectra; Vision; Zeeman Effect and Radiation in a Magnetic Field.

In Heat :—Absorption; Conductivity; Critical Points and Constants; Dilatation; Freezing-, Melting-, and Boiling-Points; Gases and Vapours; Measurements and Use of Instruments; Miscellaneous; Specific Heat and Latent Heat; Temperature; Temperatures (high and low); Thermodynamics; Thermometry and Pyrometry; Vapour Pressure.

In Sound :—All Abstracts referring to this subject have been indexed under *Sound*.

In Electricity and Magnetism :—Absorption; Alternate Current Research; Apparatus and Instruments (descriptive); Capacity (electrostatic); Conductivity and Resistivity; Dielectrics; Discharge in Gases and in Vacuo; Electromagnetic Theory; Induction (self and mutual); Magnetism; Measurements and Use of Instruments; Medical Electricity; Miscellaneous; Oscillations and Waves; Polarisation (electric waves); Polarisation (electrolytic); Resonance; Static and Atmospheric Electricity; Terrestrial Magnetism and Electricity; Thermo-Electricity and Thermo-Magnetism.

In Chemical Physics :—Absorption; Alloys; Batteries (primary); Batteries (secondary); Chemical Equilibrium; Dissociation and Ionisation; Electric Furnace Processes; Electrolysis (commercial); Electrolysis (except commercial); Electrolytic Analysis; Miscellaneous; Osmosis; Solution and Solubility; Vats and Cells (electrolytic).

In Steam Plant, Gas and Oil Engines :—Accessories (steam plant); Automobiles; Boilers; Condensers; Economisers, Feed Water Heaters and Superheaters; Gas Engines, Gas Producers, &c.; Miscellaneous; Oil Engines; Steam Engines.

In General Electrical Engineering :—Accessories and Appliances (electrical, excluding traction); Apparatus and Instruments (descriptive); Batteries (primary); Batteries (secondary); Equipment of Factories and Machine Tools; Insulation and Insulators; Miscellaneous.

In Generators, Motors, and Transformers :—Alternators; Dynamos; Miscellaneous; Motors; Rectifiers; Transformers and Rotary Converters.

In Power Transmission, Traction, and Lighting :—Accessories and Appliances (traction); Automobiles; Cables, Conductors and Wiring; Costs; Electricity and Traction Works (descriptive); Lamps (arc) and Arc Lighting; Lamps (incandescent); Miscellaneous; Power Transmission and Distribution; Traction (electric, by accumulators); Traction (excluding accumulator traction and descriptions of power stations); Traction (mechanical).

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